NEW TREATISE

ON

ASSIMILATION AND DIGESTION

SHOWING THE

DIFFERENT SOLVENT JUICES AND FLUIDS,

THIER ORIGIN AND THEIR USES IN THE HUMAN SYSTEM, THE GLANDS FROM WHICH THEY ARE SECRETED, AND THEIR RELATION TO EACH OTHER.

BY THE AUTHOR,

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OF NEW CANTON, PIKE CO., ILL.

QUINCY, ILL.:
DAILY WHIG BOOK AND JOB PRINTING HOUSE.
1878.

A Treatise on Assimilation and Digestion.

The subject of Digestion, though it has received the attention and forethought of a great many of the ablest minds of the world for many centuries, I find that, after all that has been written, the subject is yet in its infancy, and nearly every author sheds some new light upon the subject; and in my limited treatise, while I may receive the approval and commendation of a portion of the profession, yet I expect to receive the disapproval and disapprobation of another part of the profession; for it is hard to establish any new theory or principle without finding opposition at every step of progress, and more especially in the medical world. In this short treatise I shall endeavor to express my views in as brief and few words as I possibly can, as this is a preliminary work. I shall endeavor to conform to the principles already advocated by the profession, as possible and consistent with my views of physiological principles. I shall approve and adopt all theories that are founded on truth and sustained by correct reasoning, and disapprove all theories not founded on truth; and will give to the medical world all and any new ideas which will advance knowledge in general, and be a benefit to the professional world and a permanent benefit to the human family in this generation and generations hereafter.

The old established theory is, that when food is

taken into the system it is governed by laws of nutrition, or that function by which the nutritive matter, already elaborated by the various organic actions, loses its own nature and assumes that of the different living tissues, to repair their losses and support their strength. Sometimes the word is used in a more extended signification, to express the whole series of actions by which the two constant movements of composition and decomposition are accomplished in organized bodies. Nutrition, then, would comprehend digestion, absorption, respiration, circulation and assimilation; the latter being (nutrition) properly so called, and being operated in the intermediate system over the whole body, the tissues attracting from the blood the elements necessary for the reparation.

The first principle involved in the development of nutrition is Digestion, (from *digere*, to dissolve). Digestion is a function by means of which alimentary substances, when introduced into the digestive canal, undergo different alterations. The object of this is to convert them into two parts, the one a reparatory juice destined to renew the perpetual waste occurring in the animal economy, the other, deprived of its nutritious properties, to be rejected from the body. This function is composed of a series of organic actions, differing according to the particular organization of the animal economy in man. They are eight in number, to-wit: 1. Prehension of food. 2. Mastication. 3. Insalivation. 4. Deglutition. 5. Action of the stomach. 6. Action of the small intestines. 7. Action of the large intestines. 8. Expulsion of the fœces. The first principle involved: prehension of food, which means carrying food to the mouth and

introducing it into the mouth. 2d, Mastication, (from I chew), the action of chewing or bruising food to prepare it for digestion, by the united action of the tongue, cheeks and lips, which push the alimentary substances between the teeth, and by the motion of the lower jaw it is cut, torn or bruised, and by the joint action of the above named organs it excites the salivary glands, which are the two parotid, two sub-lingual and the two submaxiliary glands. The third principle involved is insalivation, which is a secretion from those three sets of glands, called saliva. Those glands manufacture the saliva from the blood by means of small blood vessels, or small arteries, and the balance of the blood is carried back into the circulation after the saliva is taken from it, by means of small veins; this substance is as clear as water, but possesses that peculiar property of dissolving almost any substance it comes in contact with. The amount secreted, according to the report of some of the most popular physiologists, is about twenty ounces in twenty-four hours by a healthy adult person of medium stature. Upon inception of food into the mouth those glands throw out a sufficient amount of saliva through the mucous membrane of the mouth to partially dissolve the food and hold it in a muco-soluble state, so that it can pass down the œsophagus by the peristaltic action of the muscles of the œsophagus into the stomach, where it undergoes a chemical change and forms a new compound. After the food passes the sphincter of the cardiac muscle into the stomach, the food is passed back and forth by an involuntary muscular action of the stomach, to bring the food into direct action of the gastric juice, a fluid secreted by the mu-

cous membrane of the stomach; and the motions of the stomach, sometimes transversly, and at other times longitudinally, not only produce a constant disturbance, or churning of the contents of the stomach, but they compel them at the same time to revolve about the interior from point to point, and from one extremity to the other. In addition to these movements, there is a constant agitation of the stomach produced by the respiratory muscles, and the constant action of the material taken into the stomach acts as an excitant for an effusion of the gastric juice, which is eliminated by the mucous membrane of the stomach to the extent of seventy-five to eighty ounces in twenty-four hours, according to the estimate of scientific physiologists. This gastric juice, according to the above estimate, would make about five pounds of a fluid avordupois weight, or in other words, over half a gallon; a liquid almost clear, and containing a very small quantity of solid material, but constituted of very peculiar properties, combining a certain fermenting principle combined with a peculiar composition of chlorides, phosphates, potash, lime, soda and magnesia, making a substance which combines the solvent properties of almost every principle displayed in nature, and that will act upon all and any substance which is placed in it, dissolving it into its primitive ingredients.

The peculiar dissolving properties contained in the gastric fluid, is not possessed by any other fluid. It has been analyzed and its primitive parts made known, but why it possesses these peculiar primitive principles is a question not easily answered. But certain it is, that it does contain certain solvent properties,

and the admixture of it with the food assists to dissolve the food, and forms a new compound, called chyme, which is a muco-perulent compound, of the appearance of milk in solution with other substances. Some physiologists say that the process of chymification goes on more rapidly when the contents of the stomach are about 98° to 100° temperature, which is required to keep up the solvent process, which is retarded according to the depression of the thermometer below the standard, so that at the ordinary temperature of the atmosphere it is completely suspended, to be renewed, however, with an increment of heat.

The next condition which specially affects the time required for the process of solution in motion: This does not act mechanically by way of trituration, as was once supposed, for food is found to be digested when enclosed in metalic balls perforated to admit the access of gastric juice to the interior. But it answers the purpose of thoroughly subjecting the whole of the alimentary bolus to the agency of the gastric solvent by bringing each part successively into contact with the lining membrane of the stomach, from the surface of which the fluid is effused. The removal of the matters already reduced or dissolved, also has a most important effect in facilitating the solution of the remainder. This chyme will, of course, vary greatly in composition, according to the proportion of the different alimentary substances that have entered into the composition of the food; and its appearance, also, is far from uniform, being sometimes like gruel, and sometimes more creamy; always, however, having a strong acid reaction. The effect of the gastric fluid upon the several kinds of albu-

minous matters, is to reduce them to a state of complete solution, and at the same time to alter their chemical properties so that they, for the most part, lose their distinctive attributes and are brought to one uniform condition, that of albuminous, which seems to be the state best adapted for subsequent assimilation. In this condition they seem to form definite combinations with the solvent fluid. Although the chyme, or product of gastric digestion, which escapes through the pyloric orifice of the duodenum, contains much oxidized matter in a state of actual solution, a considerable proportion of it is still only reduced and mechanically suspended, and the solution of the latter is continued in the intestinal tube. In the farinaceous part of the food, moreover, no great amount of change has hitherto been effected, and the sugar which has been generated by the aid of the salivary ferment, is probably absorbed into the blood vessels nearly as fast as it is formed. Hence we see that the process of digestion, so far from being completed in the stomach, has only been carried one stage further. Soon after its entrance into the duodenum, the chyme is sujected to the action of the bile, the pancreatic fluid.

The next question to be determined, is: the quantity of food to be acted upon and taken into the system, for the support of the system. The organic compounds usually employed as food by man, are partly derived from the animal and partly from the vegetable kingdom, and they may be conveniently arranged under the following heads:

1st. Saccharine group, including all those substances derived from the vegetable kingdom, which are analagous in composition to sugar, consisting of oxy-

gen, hydrogen and carbon alone, and having the first two present in the proportions to form water. To this group belong starch, gum woody fibre and cellulous of plants, which closely resemble each other in the proportion of their elements, and which may be converted into sugar by chemical process of a simple kind, whilst alcohol, which is derived from sugar by the process of fermentation, has a composition which rather connects it with the next group.

2d. The oleaginous group, including oily matters, whether derived from the vegetable kingdom or from the fatty portions of animal bodies. The characteristics of this class lie in the great predominence of hydrogen and carbon, the small proportion of oxygen and the entire absence of nitrogen.

3d. The albuminous group, comprising all those substances, whether derived from the animal or vegetable kingdom, which are closely allied to albumen, and through it to the animal tissues generally in their chemical composition. In this group a large proportiou of azote is united with the oxygen, hydrogen and carbon of the preceding.

4th. The gelatinous group, consisting of substances derived from animal bodies only, which are closely allied to gelatine in their composition. These also contain azote, but the proportion of their components differ from that of the preceding. There are many other substances, however, which, though truly alimentary, and consumed to a considerable amount, cannot be legitimately placed under either of the above heads. Such are, for example, the vegetable acids. The compounds of the saccharine group cannot, without undergoing metamorphosis, form part of the ani-

mal tissue, as there are none which they at all resemble in composition. It has been shown, however, that they are convertible within the animal body into those of the oleaginous group, and may thus, like the latter, be applied to the formation of the adipose and nervous tissues. But the amount of those substances which is thus employed is a very small part of that which is ordinarily introduced as food, and by far the larger proportion of them is made subservient to the maintenance of the heat of the body by the combustive process. The sugar, which is taken in as such, being dissolved and absorbed into the current of the circulation, appears to undergo a speedy metamorphosis into lactic acid, which is the form under which it is finally oxidized and burned off; and starch is made capable of undergoing the same change, by being first converted into sugar. During the digestive process oleaginous matters do not seem to undergo any change preliminary to their oxidation, save their reduction to a state of very fine division. We shall presently see that a very considerable difference exists between the saccharine and oleaginous matters, in regard to their calorifying powers. That none of these non-azotized substances can be made capable of metamorphosis or combination within the animal body, of taking the place of azotized substances, as histogenetic or plastic compounds may now be regarded as one of the most certain facts in physiology. The concurrent evidence of experiments and observations leading to the conclusion that in plants alone can any production of azotized compounds take place, and that animals are, in consequence, directly or indirectly dependent upon the vegetable kingdom for

their means of subsistence. If animals be fed exclusively upon saccharine or oleaginous substances of any kind, or in any combination whatever, they speedily show symptoms of inanition, and the only assistance which such food affords in the prolongation of life, is derived from its calorific power.

The application of the substances forming the albuminous group to the support of the animal body, by affording the materials for the nutrition and reformation of its tissues, and also for the maintenance of its heat: The proportions of carbon, hydrogen, oxygen and nitrogen, of which all these substances are composed, appear to be identical, and they are all capable of being reduced by the digestive process to the condition of albumen. Hence it is a matter of little consequence, except as regards the proportions of inorganic matters, with which they may be respectively united, whether we draw our histogenetic materials from the flesh of animals, from the white of of eggs (albumen), from the curd of milk (caseine), from the grain of wheat (gluten), or from the seed of the pea (legumen). Neither of these substances, however, can long sustain life when it is used by itself, for it has been experimentally ascertained that by being made to feed constantly on the same substance—boiled white of egg, for instance, or meat deprived of the principal osmazome that gives it flavor, an animal may be effectually starved; its disgust at such food being such that even if this be swallowed it is not digested.

The organized fabric of animals contain, as we have seen, a large quantity of gelatin. It seem certain that this substance may be produced out of

fibrine and albumen, since in animals that are supported on these alone the nutrition of the gelatinous tissues does not seem to be impaired. But it has been commonly supposed that gelatin, taken in as food, may serve for the growth and maintenance of these tissues, even though it may be incapable of conversion to the albuminous type. It is very doubtful, however, whether gelatin can render even this service. For all, our own knowledge of the history of the development of the gelatinous tissues would lead us to regard them as secondary products, which take their origin in fibrinous blastema, and can only be generated by the metamorphosis of protean compounds. If these views be correct, it follows that the alimentary value of gelatin must be limited to its calorific power; its hydro-carbon being separated from its highly azotized portion, and the former being oxodized and eliminated through the lungs, whilst the latter will pass off by the kidneys. And this view is confirmed by observations on the result of ingestion of large quantities of pure gelatin, this being a marked increase in the proportion of urea in the urine, with an elevation of its specific gravity. Neither leucine or glycine could be detected in the fluid, so that gelatin seems to be subjected to the same metamorphosis that the protean compounds undergo when they are taken in excess. That gelatin cannot take the place of the albuminous compounds has been fully demonstrated; in so far, therefore, as the only azotized principle contained in soups, broths, &c., are of the gelatinous character. We must account these preparations as destitute of the power of nourishing the body; and the peculiar nutritive value

which experience shows that such perparations possess in certain states of the system, must be attributed to the albuminous matters which they hold in solution, and to the readiness with which their gelatinous constituents are absorbed and applied to the purpose of calorification.

The substances which cannot be arranged under either of the preceding groups, are, for the most part, of the non-azotized class, and as they mostly consist of compounds in which the hydrogen and carbon are not combined with their full equivalents of oxygen, they are made to contribute to the calorifying process by undergoing oxidation within the system, so as to be excreted in the form of carbonic acid and water.

By rules based on the foregoing data, then, we may estimate the relative value of different articles of food for the two distinct purposes of tissue formation and the production of heat. For the proportion of albuminous matter which any substance may contain furnishes the measure of its histogenetic value, whilst the proportion of hydro-carbon uncombined with oxygen, affords the means of estimating its calorific power when oxidized. As in almost every alimentary substance, whether vegetable or animal, the two classes of compounds are mingled; the percentage of nitrogen which it may contain affords a tolerably correct measure of the amount of albuminous matter which it includes, and therefore of its histogenetic value; where, on the other hand, the percentage of nitrogen is the smallest, that of hydro-carbon is the largest, and the proportion of the combustive material is the highest. It is obvious that the most economical diet will be that in which there is the most

perfect apportionment of each class of constituents to the wants of the system, and these will vary with the amount of muscular exertion put forth, and the lowering of the external temperature. Thus, for a man of ordinary habits, and living under a medium temperature, a diet composed of animal flesh alone is the least economical that can be conceived; for since the greatest demand for food in his system is created by necessity for a supply of carbon and hydrogen to support his respiration. This want of non-azotized food in which these ingredients predominate. Thus it has been calculated that since fifteen pounds of flesh contain no more carbon than four pounds of starch, a savage with one carcass and an equal weight of starch could support life for the same length of time during which another, restricted to animal food, would require five such carcasses to procure the carbon necessary for respiration. Hence we see the immense advantage as to economy of food which a fixed agricultural population possesses over those wandering tribes of hunters which still people both the old and new continents. This mixture of azotized and non-azotized compounds (gluten and starch) that exists in wheat flour, seems to be just that which is most generally useful to man, and hence we see the explanation of the fact, that from very early ages, bread has been regarded as the staff of life. There are particular conditions of existence, however, under which life may be advantageously supported upon animal food alone. The Esquimaux, and other dwellers upon the Arctic seas, find in the bodies of the whales, seals, &c., whereon they subsist, that special supply of the very best combustive material

which alone can enable them to maintain their existence, where the thermometer is for many weeks or months in the year at 40°, or even lower, and where the amount of heat which must be generated within the body is four or five times that for which a diet of bread will suffice. On the other hand, the general experience of the inhabitants of warm climates seems in favor of a diet chiefly or entirely vegetable, and its peculiar suitableness appears to consist in its affording an adequate supply of the plastic alimentary substances in combination with farinaceous matters, that give the requisite bulk to the food without affording more combustive material than the system requires. The quantity of starch which undergoes conversion, and is introduced as sugar into the circulation, being apparently governed rather by the demands of the respiratory process than by the amount ingested, and the remainder being voided again unchanged. The mixed diet, to which the inclination of man in temperate climates seems to lead him, appears to be fully conformable to the construction of his dental and digestive apparatus, as well as to his instinctive propensities.

If, indeed, we take a comprehensive survey of the conditions of the various races of man at present inhabiting the earth, we cannot help being struck with his adaptiveness to a great variety of circumstances as regards climate, mode of life, diet, &c. And we scarcely avoid the conclusion that the Creator, by conferring upon him such an adaptiveness, intended to qualify him for subsisting on these articles of diet, whether animal or vegetable, which are most readily attainable in different parts of the globe, and thus to

remove the obstacle which a necessary restriction to any one kind of food would have otherwise opposed to his universal diffusion. If we were to bring together the habitual diet scales of the several races of men which people the surface of the globe, we apprehend that the diversities which they would present would be scarcely less strange than those which exist among the regimens of the most dissimilar species of mammalia. In the various devices by which man has succeeded in availing himself of these, and in the various tastes which have led some to avail themselves of articles of food which others would loathe, we see the same wise design as that which has given to different tribes of animals their respective preference; and we deduce from the whole the conclusion that man is left by his Creator at perfect liberty to select that kind of nutriment which he finds most suitable to his tastes and to his wants; the former, when not absolutely vicious, being an exponent of the latter, just as the simple desire for food is the exponent of the need for it in the system. When the results of experience then are combined with the teachings of science, they seem to justify the following conclusions: That a due adjustment of the albuminous and saccharine constituents of the food to the varying conditions under which man exists, is of the first importance, and that the question of the derivation of the first two of those constituents, from the animal or from the vegetable kingdom, is one of a secondary character, each being capable of yielding them in adequate amount; and the only condition requisite being that the articles of food shall be so selected as to supply the needful quantity. Thus a diet

whose staple consists of potatoes or rice contains by far too small an amount of albuminous matter in proportion to farinaceous, but if to this be added a moderate quantity of meat, the proportion is assimilated to that which exists in wheaten bread, which may be taken as the standard for man's alimentation in all but extremely cold climates. The failure of wheaten bread to supply what the system there requires, depends on nothing else than its deficiency in the oleaginous constituent; for, although such a craving for fat meat is experienced by travelers in those climates, as has led to the belief that it is necessary for their support, the same kind of difference should be made in the winter and summer diet of the inhabitants of the temperate zone. For when the external temperature is low an ample supply of oleaginous matter is indicated and may be advantageously taken in the form of butter, cocoa, fat meat or maze bread. On the other hand, during the heat of summer, the more nearly the diet is assimilated to that of the natives of tropical climates in the substitution of fruits and farinacea for oleaginous articles, the less will be the liability to disordered health in the autumn. Experience teaches that it is not a matter of entire indifference whether the albuminous constituent be drawn from the animal or from the vegetable kingdom, for the use of highly animalized diet has a tendency to raise, and that of a vegetable diet to lower the proportion of red corpuscles in the blood, whilst by a due adjustment of the proportion of the two classes of components, the evil effects of the exclusive use of either may be prevented. The absolute quantity of food required for the maintenance of the human body in health, varies

so much with the age, sex, constitution and habits of the individual, and with the circumstances in which he may be placed, that it would be absurd to attempt to fix any standard which should apply to every particular case. The appetite is the only sure guide for the supply of the wants of each, but its indications must not be misinterpreted. To eat when we are hungry is evidently a natural disposition, but to eat as long as we are hungry may not always be prudent. Since the feeling of hunger does not depend so much upon the state of fullness or emptiness of the stomach as upon the condition of the general system, it appears evident that the ingestion of food can not at once produce the effect of dissipating it, though it will do so after a short time. So that, if we eat with undue rapidity, we may continue swallowing food long after we have taken as much as will really be required for the wants of the system, and every superfluous particle is not only useless, but injurious. Hence, besides its important ends, the process of thorough mastication is important as prolonging the meal, and giving time to the system so that its demands may be abated in due time to prevent the ingestion of more than is required. There seems to be a sense of perfect intelligence conveyed to the encephalic centre, which, in health, invariably dictates what quantity of aliment is naturally required for purposes of life, and which, if noticed and properly attended to, would prove the most salutary monitor of health, and an effectual preventive of disease. It is not the sense of satiety, for this is beyond the point of healthful indulgence, and is nature's earliest indication of an abuse and overburden of her powers to re-

plenish the system. It occurs immediately previous to this, and may be known by the pleasurable sensations of perfect satisfaction, ease and quiesence of body and mind. It is when the stomach says enough, and it is distinguished from satiety by the difference of sensations, the latter saying too much. Every medical man is well aware how generally this rule is transgressed; some persons making a regular practice of eating to repletion, and others paying far too little attention to the preliminary operations, and thus ingesting more than is good for them, even though they may actually leave off with an appetite.

Although no universal law can be laid down for individuals, however, it is a matter of much practical importance to be able to form a correct average estimate. It is from the experience afforded by the usual consumption of food by large bodies of men that our data are obtained, and these data are sufficient to enable us to predict with tolerable accuracy what will be required by similar aggregations, though they can afford no guide to the consumption of individuals. We shall first consider the quantity of food sufficient for men in regular active exercise, and then inquire how far that may be safely reduced for those who lead a more sedentary life. It is well known that an extraordinary improvement has taken place in the health of seamen in the last few years. At present it may safely be affirmed that it would not be easy to construct a diet scale adapted to answer the required purpose than the diet scale of the United States army, which is from forty-one to fifty ounces in twenty-four hours. Of this thirty-five ounces is vegetable and the balance animal; and these can not be re-

garded as superfluous, as there can not be any complaint of insufficiency of food. For this is found to be amply sufficient for the support of an able-bodied man under the different conditions and exposures to which a soldier is subjected. The judicious admixture of the vegetable acids and canned fruit with the other articles of diet has been found to be greatlv efficacious in warding off scurvy, which used to be, at one time, so greatly dreaded. By diminishing the amount of alkali in the blood, and by giving non-nitrogenous food, the scurvy is cured or prevented in consequence of such substances being acted on instead of the tissues of the body. No other explanation can be given of the benefits which arises from vegetable acids from fresh vegetables, from sugar, potatoes, &c. The importance of a variety of food need scarcely be insisted upon when the number of principles entering into the composition of the human body is remembered. The living body has no power of creating elementary substances. It is obvious, therefore, that the system must be supplied with food containing all the elements which enter into its composition. In case of prisoners the diet should, of course, be as spare as possible consistently with health, but it should be carefully modified in individual cases according to several collateral circumstances, such as depression of mind, compulsory labor, previous intemperate habits, and especially the length of confinement. It has been supposed by some that prisoners require a fuller diet than persons at large; this is probably erroneous, but more variety is certainly desirable to counteract, as far as possible, the depressing influence of their condition upon the di-

gestive powers. The evil effect of an undue reduction in the supply of food, and insufficient attention to its quality, has, unfortunately, been too frequently displayed in our prisons. A notable example of which will be hereafter alluded to. It is not enough for the healthy support of the body that the food ingested should contain an adequate proportion of alimentary constituents; it is important that these should be in a wholesome or undecomposed state. Water constitutes the natural drink of man, and that no other liquid can supply its place is apparent from the large proportion of the body that is formed by it; the influence which its presence exerts on the physical properties of the various tissues into which it enters, and the number a variety of purposes to which it is subservient in chemico-vital operations of the living body is unquestionable. The quantity of water in the different tissues of the system amounts to two thirds the weight of the entire system. When we examine into the uses of this large proportion of water we find, in the first place, that it serves a purpose simply mechanical, imparting to the tissues that supleness and extensibility which characterize them in their natural state, but which are completely removed by drying them. The tissues in which we find least water are those whose functions are most purely physical. Thus we see that bone, whose sole office is to afford an inflexible support, contains no more than ten to twenty per cent. of fluid; the principal part even of this belonging to the softer tissues immediately connected with its nutrition. So in the cuticle and its appendages, whose purpose is merely protective, and which are partly dessicated by ex-

posure to the air, the proportion of solid matter is at least half. But further, the presence of water is essential to the performance of all those chemico-vital processes by which the integrity of the living body is maintained, and deficiency in aqueous portion of the fluids soon manifests itself in a disturbance of these operations, even though the constitution of the solid tissues may have not been affected. As a general rule it may be stated that no chemical action takes place between solid substances, and that they require to be dissolved in water or some other menstruum before they can be made to affect each other; and we find that this rule holds good constantly in the organized fabric alike of plants and animals. No alimentary material can be appropriated by the organism save in the liquid form, and hence it is that animals, whose food is solid, are endowed with a digestive apparatus for its reduction to the state in which it may be absorbed by the sanguiferous and lacteal vessels, which answer to the rootlets of plants; this state being either one of complete solution or of very minute division. No other liquid than water can thus act as a solvent for the various articles of food introduced into the stomach. Again, it is water which continues to form the solvent of the nutritive materials after they have found their way into the current of the circulation, and have undergone that assimilating process which prepares them for being applied to the renovation of the solid tissues, and of the vital fluid which courses in minute streams through nearly every part of the body, vivifying and renovating the tissues which it traverses. Water constitutes as much as 75 to 80 per cent. So again it is

the water of the blood which not merely brings to the living tissues the materials of their development in a state ready for appropriation, but also takes up the products of their disintegration and decay and conveys them by a most complicated and wonderful system of sewerage out of the system. It is not difficult to understand, then, how seriously the chemico-vital operations of the body must be effected by a deficiency in the normal proportion of this liquid, more especially as some of the substsnces to be transported are of a difficult solubility; and we find that the demand for it, when it is withheld, soon becomes even more pressing than the demand for solid food.

A very small amount of putrescent matter in our food is quite sufficient to produce the most pernicious results, when that matter is habitually introduced into the system, and these results, on the one hand, manifest themselves in the production of certain disorders which appear distinctly traceable to the direct action of the poison so introduced; whilst on the other hand they become apparent in the extraordinary augmentation of the liability to attacks of such zymotic diseases as may, at the time, be prevalent. The various beverages employed by man, for the most part, consists of water holding solid matter of different kinds in solution, and it is not requisite, therefore, to bestow any special attention upon them; but the use of alcohol, in combination with water, and with organic and saline compounds in the various forms of fermented liquors, deserves particular notice, on account of the numerous fallacies which are in vogue respecting it. In the first place, it may be safely affirmed that alcohol can not answer any one of those

important purposes for which the use of water is required in the system; and that, on the other hand, it tends to antagonize many of those purposes by its power of precipitating most of the organic compounds whose solution in water is essential to their appropriation by the living body. Secondly, the ingestion of alcoholic liquors can not supply anything which is essential to the due nutrition of the system, for we find not only individuals, but whole nations maintaining the highest vigor and activity, both of body and mind, without ever employing them as an article of diet. Thirdly, there is no reason to believe that alcohol, in any of its forms, can become directly subservient to the nutrition of the tissues, for it may be certainly affirmed that, in common with non-ozotized substances in general, it is incapable of transformation into albuminous compounds; and there is no sufficient evidence that even fatty matters can be generated in the body at its expense. Fourthly, the alimentary value of alcohol consists merely in its power of contributing to the production of heat by affording a pabulum to the respiratory process; but for this purpose it would be pronounced, on chemical grounds alone, to be inferior to fat; and the result of the experience of Arctic voyagers and travelers is most decided in regard to the low value of alcohol as a heat producing material. Fifthly, the operation of alcohol upon the living body is essentially that of a stimulus, increasing, for a time, like other stimuli, the vital activity of the body, and especially that of the nervo-muscular apparatus, so that a greater effect may often be produced in a given time under its use than can be obtained without it, but followed by a correspond-

ing depression of power which is the more prolonged and severe in proportion as the previous excitement has been greater. Nothing, therefore, is in the end gained by their use, which is only justifiable where some temporary emergency can only be met by a temporary augmentation of power, even at the expense of an increased amount of subsequent depression; or where it affords aid in the introduction of aliment into the system, which nothing else can so well supply. These cases, however, will be less numerous in proportion as due attention is paid to other means of promoting health, which are more in accordance with nature. The physiological objections to the habitual use of even small quantities of alcoholic liquors, rest upon the following grounds: They are universally admitted to possess a poisonous character when administered in large doses, death being the speedy result, through the suspension of nervous power which their introduction into the circulation in sufficient quantity is certain to induce. When habitually used in excessive quantities, universal experience shows that alcoholic liquors tend to produce a morbid condition of the body at large, and especially of the nervous system. This condition being such as a knowledge of its *modus operandi* on the body would lead the physiologist to predicate the frequent occurrence of more chronic diseases of the same character among persons advanced in life who have habitually made use of alcoholic liquors in moderate amount, affords a strong probability that they result from a gradual perversion of the nutritive processes of which that habit is the cause. The special liability of the intemperate to zymotic diseases, indicates that the

habitual injestion of alcoholic liquors tends to prevent the due elimination of the products of the disintegration of the system, and thus to induce a fermentible condition of the blood. Extended experiencd has shown that, notwithstanding the temporary augmentation of power which may result from the occasional use of fermented liquors, the capacity for long endurance of mental or bodily labor, and for resisting the extremes of heat and cold, as well as other depressing agencies, is diminished, rather than increased, by their habitual employment. On these grounds, the author has felt himself fully justified in the conclusion that for physiological reasons alone habitual abstinence from alcoholic liquors is the best rule that can be laid down for the great majority of healthy individuals, the exceptional cases in which any real benefit can be derived from their use being extremely few.

After treating on the course of the food that is necessary for the support of the system in a normal condition; the different actions it has to undergo before it is taken into the stomach; the chemical changes it undergoes in the stomach; the different kinds of food that enter into the composition of mas aliment; the diffusion of food to man under different latitudes and conditions in which he may be placed; the different changes in the food of different kinds, and the attendant circumstances under which he be placed, has been as briefly and concisely set forth as is possible in these few pages. The next important organ of digestion which I shall refer to is the Pancreas. I shall not endeavor to give an anatomical or physiological description, but merely its office and use in assisting to dissolve the food and encourage digestion.

It was a disputed point for many years what its office really was, but after faithful research it was demonstrated by scientific men that it did secrete a fluid which was essential to the decomposition of the food; but we will briefly say that the chyme, or product of gastric digestion, which escapes through the pyloric orifice into the duodenum, contains much azotized matter in a state of actual solution; a considerable proportion of it is still only reduced and mechanically suspended, and solution of the latter is contained in the intestinal tube. In the farinaceous part of the food, moreover, no great amount of change has hitherto been effected, and the sugar which has been generated by the agency of the salivary ferment, is probably absorbed in the blood vessels nearly as fast as it is formed. In the condition of the fatty matters no important change is perceptible, except such as results from the solution of the membranes, &c., that enclosed them. Hence we see that the process of digestion, so far from being completed in the stomach, has only been carried one stage further. Soon after its entrance into the duodenum, the chyme is subjected to the action of the bile, the pancreatic fluid, and that secretion from the glandular in the walls of the intestine itself from the glands of brunner. Such follicles present themselves along the whole extent of the gastro-intestinal mucous membrane, but although very similar in their appearance, in different parts of its length their secretion is probably very different. Along the course of the intestines, on the other hand, it is doubtful whether they form any other secretion than that of protective mucous. Such follicles are not known to exist in any other than the open state,

and they seem to have a permanent character, continually discharging new broods of epithelial cells. Various parts of the mucous membrane of the stomach, and of the large intestine, are studded at intervals with shallow pits, or follicles, which, according to observation, have the form of closed vesicles during fœtal life and early infancy, but gradually open so that their cavities become continuous with the free surface of the mucous membrane, the columnar epithelium of which extends itself into them and they remain in that condition during the rest of life.

The pancreatic fluid will be first noticed. The structure of the pancreas closely resembles that of the salivary glands, for it consists of racemose clusters of secreting follicles, which form the terminations of the ramifying divisions of the duct; each cluster, with its blood vessels, lymphatic nerves and connecting tissues, forming a lobule, and the separate lobules being held together by areolar tissue as well as by the vessels and ducts. Like the salivary glands, its development commences by a sort of budding forth of the alimentary canal at a particular spot upon which a mass of cells has previously accumulated. The secretion of this gland strongly resembles saliva in its general appearance, being clear and colorless, slightly viscid and alkaline in its reaction. It contains a large proportion of solid matter, and the nature of its animal principle is not precisely the same. The albuminous ferment is not perfectly coagulable by heat, and when precipitated by sulphuric, nitric and concentrated hydrochloric acids, and by the metalic salts, and when thrown down by these or by heat, it is redissolved in an excess of the reagent, and

on the application of heat and this solution it is precipitated by ferrocyanide of potassium. When boiled with ammonia it assumes an intense yellow color. The readiness with which this substance undergoes change is indicated by the rapidity with which the pancreatic fluid passes into decomposition, for even after a few hours exposure to the air it gives off a decidedly putrid odor. Like ptyaline, this peculiar constituent of the pancreatic fluid possesses the power of converting starch into sugar. There can be no doubt, therefore, that it is subservient to the continued digestion of the farinaceous part of the food during its passage through the small intestines. It shares this office, however, with the success of the enteritis, which has been shown to be possessed of this converting power. It has recently been affirmed, and strong evidence has been adduced, that the essential purpose of the pancreatic fluid is to promote the absorption of fatty matters by reducing them to the state of an emulsion, which is capable of finding its way into the lacteals. That this fluid possesses the emulsifying power in a peculiar degree, may be considered as having been fully demonstrated by experiments, for mixing it with oil, butter, or any variety of fat, at a temperature sufficiently high to render the fatty substance liquid, and then stirring the mixture a few minutes, an emulsion is produced bearing a strong resemblance to chyle. This emulsion does not cease to present its peculiar aspect, although left standing for some time; whereas, although bile, saliva, gastric juice, blood-serum and other animal fluids have a certain emulsifying power, yet after a short time the oil particles run together again almost

as if they had been shaken up with water. When fatty matters have been introduced into the alimentary canal they undergo no considerable change until they have passed the orifice of the pancreatic duct, and oily emulsion being then for the first time found in the intestinal canal, and the contents of those absorbents only having the opaque whiteness of chyle, which originate in the intestinal villi below that orifice. So again, by putting a ligature round the pancreatic duct, the digestion of the oleaginous matter is so completely prevented that it is found in the lacteals. This position is further strengthened by the fact ascertained by chemical observation, that there is a close relation between disease of the pancreas and the discharge of fatty matters per anus. That the digestion and absorption of fatty matters will take place after the pancreatic duct has been tied, (sufficient time having been given for the evacuation of any pancreatic fluid which may have been in the alimentary canal previously to the operation), and even in the lower part of the small intestines into which these substances have been conveyed by ingestion, after it has been completely separated by a ligature from the upper part into which the pancreatic fluid has been poured. It further appears from these experiments, that a mixture of the pancreatic fluid with the bile and the succus entericus possesses a more energetic emulsifying power than the first of these fluids alone; and it seems probable that, as in the conversion of starch, so in the emulsification of fat the intestinal fluid performs a very important part. It would not seem unlikely that the qualities of these fluids, like those of the saliva, may vary in different animals, and

that the emulsifying power may be limited in the rabbit, or nearly so, to the pancreatic fluid; the quantity of fat which its natural food contains being small, whilst in the carniverous animals whose natural food is more oleaginous, the provision for the digestion of fatty matters may be more extensive. Of the amount of pancreatic fluid which is daily secreted by man, we have no other data for forming an estimate than those afforded by Frerichs, who collected from an ass in forty-five minutes, 387½ grains, and from a large dog, in twenty-five minutes, 46 grains. These amounts, however, were poured forth while food was in the stomach and digestion was going on, and it is probable that at other times the secreting process is nearly suspended. The duodenum receives not only the pancreatic, but also the biliary secretion, and from the constancy with which this fluid is poured into the upper part of the intestinal tube, or even into the stomach itself, in all animals which have any kind of hepatic apparatus, it seems a legitimate influence that this secretion is not purely excrementitious, but serves some important purpose in the digestive process. It is not easy, however, to state with precision what this purpose is. The result of many of the experiments which have been made to determine it are vitiated by the fact that the pancreatic duct, in most cases, discharges itself into the intestinal tube at the same point with the hepatic, and has thus been frequently involved in operations performed upon it, as the most important constituents of bile.

Regarding the organic compounds, we have now to consider our knowledge is far less definite and satisfactory than it is respecting those which have been

already passed in review, and this arises from several causes, among which may be more particularly mentioned the great facility with which they are decomposed, both spontaneously and by the operation of reagents, so that it is by no means easy to say, in many instances, whether a given substance extracted from the bile by analytical operations pre-existed in it or has been subsequently found under the treatment to which that fluid has been subjected. There has, consequently, been a discrepancy of opinion among chemists with regard to constitution of this excretion; some having regarded as original components what others have considered as secondary, and the number of proximate constituents having been ranked high by some while others have reduced it to some four or five. The biliary matter is chiefly composed of two substances, which are regarded as conjugated acids formed by the union of one and the same acid, the true choleic with glycine and taurine respectively, and hence termed the glyco-choleic and tauro-choleic. This choleic is a fatty, or rather a resinous, acid, from which nitrogen is altogether absent, while oxygen is present in only a small proportion. It forms tetrahedral, or more nearly square octohedral, crystals, which effloresce on exposure to the air. Its taste is bitter, leaving a faint, sweetish after-taste. The acid reaction of this substance is sufficiently strong to redden litmus paper and to enable it, with the aid of heat, to expel the carbonic acid from solutions of the alkaline carbonates. The salts which it forms possess a bitter, and, at the same time, a slightly sweet taste. They are all soluble in alcohol, but water dissolves only the chlorates of the alkalies and the baryta.

The salts of choloidic acid are perfectly isomeric with those of choleic acid, but it is that the former acid is displaced even by carbonic acid, although with the aid of heat it decomposes the carbonates. Choleic acid may be recognized wherever it occurs, whether combined with its adjuncts as a conjugated acid, or metamorphosed into choloidic, by the excellent test devised by its peculiar reaction with sugar and sulphuric acid; for if in the fluid suspected to contain bile there be first added a little solution of sugar, and pure sulphuric acid be then added by drops, a yellowish color is produced, deepening to a pale cherry, then to a carmine, and lastly to an intense violent tint, if bile be present. This test may, therefore, be applied to determine the presence or absence of the characteristic components of bile, and we shall hereafter notice some of the results of its application.

When choloidic acid is distilled with nitric acid it yields the volatile acids. The coloring matter of the bile is a substance peculiarly difficult to obtain satisfactorily, owing especially to the very small quantity in which it occurs, and to its extreme instability. The most frequent form under which it presents itself is that of a brown non-crystaline powder, devoid of taste and smell; insoluble in water; very slightly soluble in ether, and more so in alcohol, to which it communicates a distinct yellow tint. This substance constitutes a large part of most biliary calculi, in which it exists in a state of insoluble combination with lime. When it is dissolved in alkaline solutions, these which are at first a clear yellow, become, by exposure to the air, of a greenish-brown tint, and it is on this modifidation the consequence, probably, of

a higher oxidation, that the well-known changes of color which occur in some of the animal fluids are dependent. The yellow alkaline solution, when treated with nitric acid, becomes first green, then blue and then red; after a considerable period the red again passes into a yellow color, but the nature of the substance is then entirely changed. When the yellow alkaline solution is treated with hydrochloric acid, the pigment is precipitated with a green tint; this precipitate forms a red solution with nitric acid and a green solution with the alkalies, and appears to be perfectly identical with the green modification of bile pigment. When acids are added to the fresh bile, a green color is produced if oxygen be present, but not if it be excluded. Bile pigment is occasionally found in the urine in large quantities when its secretion by the natural channel is prevented, and it may be readily recognized by the nitric acid test. There is much uncertainty in regard to the precise composition of this substance, for the reasons already specified; the analysis which have been made of it, however, indicate that it is remarkable for the enormous proportion of carbon which it contains. The only distinct indication yet obtained that the characteristic components of bile are performed in the blood, is afforded by the experiments of Kunde, who demonstrated by Pettekoffer's test, the presence of biliary matters in the blood of frogs, whose livers had been extirpated. On the other hand, there is much that indicates, if it does not prove, that the function of the liver is not the mere selection and elimination of the elements of bile from the blood, but that it exercises a most important transforming power, both over the constituents of the

blood and over those of the bile. At present it will be sufficient to remark, that whilst a chemical comparison of the elements of the bile and urine shows that each of these excretions is the complement of the other, and that the mass of the blood, or of the solid tissues, might resolve itself into these two sets of compounds, various physiological and pathological phenomena seem to indicate that the products of the metamorphosis of the tissues, which afterwards become the components of bile, do not take the form of these components until they have been acted upon by the liver and reduced to a state comparatively innoxious; for whilst there is abundant evidence that the constituents of bile, both its resinous acids and its coloring matter, may be reabsorbed without serious injury, and whilst there is strong reason to believe that, as regards the resinous acids, such reabsorption is habitual, there is adequate proof, on the other hand, that the retention within the circulating current of the matters from which bile is formed, owing to structural disease or functional inactivity of the liver, is attended with the most serious consequences, and will, if prolonged, induce a fatal result.

We shall here limit ourselves to the consideration of what may be regarded as the best established facts in regard to the uses of the biliary secretion in the digestive process. When its action is tested out of the body by mingling it with the different constituents of food, it is found to exert no change upon starchy substunces while it is fresh, though when in a state of incipient decomposition it acts upon them as other animal substances do. It has no action upon cane sugar until it has stood a considerable length of time, but

then it converts it into lactic acid. This change it speedily exerts, as do all other animal substances, even when acidulated; and though it will form an emulsion with oleaginous matter, yet emulsification is less complete than that which is effected by the pancreatic fluid alone; but the same similarity exists in the salivary gastric juice, pancreatic juice, biliary secretion and the secretion from the mucous membrane of the bowels. When there is a deficient secretion of bile, or more food is swallowed than the bile provided for it can act upon, or the character of the biliary secretion itself has undergone any serious perversion, there should be a much larger amount of putrifactive fermentation than is normal, as indicated by an evolation of flatus and very frequently by diarrhœa. Further, the want of proper neutralization of the gastric fluid will cause the continuance of acidity in the contents of the intestinal canal which, in its turn, induces a state of irritaition of its mucous membrane and a perversion of its secretions, and it is one of the beneficial results of alterative medicines, employed to remedy this condition, that by augmenting the secretion of bile they tend to reproduce a state of neutrality in the contents of the alimentary canal. The presence of a proper quantity of bile in the intestines appears to promote the secreting action of the intestinal glandula, and also to contribute to maintain the peristaltic movement of the walls of the canal. This appears alike from the tendency to constipation which is usually consequent upon the deficiency of the secretion, and from the diarrhœa which proceeds from its excess, and is confirmed by the purgative properties which inspissated ox-gall has been found

to possess. Notwithstanding all its uses, however, it must be admitted that the prevention of the dlscharge of bile into the alimentary canal is not attended with the deleterious effects which might have been anticipated from it, for it has been found that if the bile duct be divided and a tube be inserted in such a manner as to convey away the secretion through a fistulous orifice in the abdominal parietes, the animals thus treated may live for weeks, months or years, and suffer no inconvenience. Of the quantity of bile daily poured into the alimentary canal of man, we have no other mode of forming an estimate than by observing the quantity poured out from the bile ducts of animals. In such experiments Blondlet found that a dog, in which he had established a fistulous opening for the discharge of bile, secreted about seven ounces in twenty-four hours. The carefully conducted observations of Budder and Schmidt indicate that the rate of secretion is by no means uniform, but that it bears a certain relation to the digestive process, the quantity poured forth in a given time being greatest about ten or twelve hours after a full meal, and then diminishing until it reaches its minimum, for which about as many more are required. The secretion is considerably diminished when food is withheld for some time; the quantity poured out after ten days' starvation being only about one eighth of what it is when at its maximum. Still it is obvious that, although its rate is thus greatly influenced by the stage of the digestive process, (which is formed from blood that is charged with newly absorbed and imperfectly assimilated matters), the excrementitious character of the secretion require that its elimination shall be con-

stantly going on to a certain degree; but a receptacle is provided in man, as in most others among the higher animals whose digestion is performed at intervals, for the storing up of the fluid until it can be usefully employed in that process. The intestinal orifice of the ductus choledocus is closed by a sort of sphincter, and the fluid secreted during the intervals of digestion, not being propelled with force sufficient to dilate this, flows back into the gall-bladder which dilates to receive it. The presence of food in the duodenum seems to excite the walls of the gall-bladder and of the biliary ducts to a contraction sufficiently powerful to propel their contents into the intestines in spite of the opposition of the sphincter, but whether this takes place through a reflex action of the nervous system, or through the direct stimulation of the muscular coat of the duct by the passage of alimentary matters over its surface, we have at present no means of satisfactorily determining. It will be recollected that the gall-bladder is usually found distended with bile in cases of death from starvation, notwithstanding the diminution in the amount secreted. The fluid of the small intestines, which is compounded by the intermixture of the biliary and pancreatic secretions with the salivary and gastric fluids, and with the secretion of the intestinal glandula, appears to possess the very peculiar power of dissolving, or of reducing to an absorbable condition, alimentary substances of every class, thus possessing more of the character of a universal solvent than either of these secretions has in its separate state. It completes the conversion of starchy into saccharine matter, and thus enables the former to supply the

blood with an important pabulum for the combustive process, which is at once absorbed into the blood vessels. It emulsifies the oleaginous matter, and thus renders it capable of being introduced into the lacteals; and it not only restores to a state of solution the albuminous compounds which may have been precipitated by the addition of bile to the product of gastric digestion, but it also exerts a powerful solvent influence upon albuminous substances which have not been submitted to the previous agency of the gastric fluid; and it thus completes the solvent process which had been very far from perfected in thé stomach. What is the precise share, however, of each of these secretions in producing this composite result, can not be stated with any degree of certainty, but it seems probable that the secretions of the intestinal walls have a very definite share in it. It is obvious that the amount of each kind of alimentary substances than can be thus prepared in a given time, will vary with the amount of the secretion, by whose agency this preparation is specially affected, and as there are many indications that the quantity of each that is taken up in absorption is limited, and that it bears a relation to the wants of the system, it is probable that the amount of the solvent, or reducing fluid, that is secreted by each glandular apparatus, is regulated, as we have seen it to be in the case of the gastric juice, by the demand set up by the nutrient operation, rather than by the amount of alimentary matter that is waiting to be digested. The process of digestion and conversion are probably continued during the entire transit of the alimentary matter along the small intestines, and at the same time the products of that con-

version are gradually being withdrawn by absorbent action, so that by the time it reaches the cæcum the undigested residue contains little else than the innutritious or insoluble component of the food, together with the excrementitious portions of the bile and other secretions. Up to this time the contents of the canal have an alkaline reaction, but in the cæcum they again become acid, and, it is supposed, that this change depends upon the secretion of a fluid analogous to the gastric juice, by the large and numerous tubular glands contained in the parietes of this part, whereby the albuminous matters, still undigested, might be more completely dissolved. This supposition appeared to derive weight from the fact that the cæcum is peculiarly large in most herbiverous animals; the appendix vermiformis being also of greatly increased dimensions, and sometimes double. But from the experiments and observations of Blondlet, it seems probable that the acid of the cæcum is rather a product of the transformation of saccharine substances in the alimentary canal than a secretion from its walls. Still as this lactic acid has a solvent power for albuminous matters, which is equal, or nearly so, to that exerted by hydrochloric acid, it is by no means impossible that it may be subservient to the completion of the digestive process, in the case in question, since the larger the proportion of the aliment composed of saccharine matters, the greater will be the importance of a thorough extraction of its albuminous constituents. The walls of the lower part of the small intestines are beset with elevated patches that are formed by the aggregation of the bodies known as the Peyerian glandula. Bodies of a similar kind, however,

also occur separately, and are known as the glandula solitaire. The glands of Peyer, when examined in a healthy mucous membrane, presents the appearance of circular, white, slightly raised spots, about a line in diameter, over which the membrane is usually less set with villi, and very often entirely free from them. Each of these white spots, of which a large number are contained in the agminated glands, is surrounded by a zone of openings, like those of the follicles of Lieberkuhn, which lead into tubular cæcal. The Peyerian glands must be regarded as instruments for the elaboration of the chyle, which is conveyed to them by the very delicate absorbents that originate in the villi. The walls of the large intestines contain a considerable number of glandula which closely resembles the glandula solitaire of the higher part of the canal; these, however, are so much more frequently open than closed that the latter condition was not recognized until pointed out by Dr. Baly. It can scarcely be doubted that these are secreting organs destined to pour the product of their activity into the alimentary canal; but whether this product be the peculiar mucous with which the coats of the large intestines are covered, or consists of the proper fœcal matter, or be something different from either, has not yet been determined. The indigested residue of the food mingled with the products of secretion that have been poured into the alimentary canal, gradually acquires, in the large intestines, the ordinary consistency of feces, through the continuance of the absorbent process, whereby the superfluous fluid is removed. The changes ensue most rapidly in the flesh of fish and hares, and less rapidly in

that of poultry and other animals; the fragments of muscular tissue which remain aftter the continued action of the digestive fluid, do not appear to undergo any alteration in their passage through the rest of the intestinal canal, for similar fragments may be found in feces even twenty-four hours after the introduction of meat into the stomach. The cells of cartilage and fibro-cartilage, except those of fish, pass unchanged through the stomach and intestines, and may be found in the feces. The intestinal tissues of these structures are converted into pulpy, textureless substances in the artificial digestive fluid, and are not discoverable in the feces. Elastic fibres are unchanged in the digestive fluid; fatty matters are also unchanged; fat cells are sometimes found quite unaltered in the feces, and crystals of cholesterine may usually be obtained from feces, especially after the use of fat pork. As regards vegetable substances, Dr. Rawitz states that he frequently found large quantities of cell membranes unchanged in the feces; also starch cells deprived of only part of their contents. The green coloring matter was usually unchanged. The walls of the sap-vessels and spiral vessels were quite unaltered by the digestive fluid, and were usually found in large quantities in the feces; their contents, probably, were removed.

Besides the undigested residue of food, the microscope enables us to recognize the brown coloring matter of the epithelium cells and mucus-corpuscles and various saline particles, especially those of the ammonaco-magnetisan phosphate, whose crystals are well defined; most of which are derived from the secretions. The quantity of fœcal matter which is daily

passed by an adult seems to average from four to six ounces, but this contains seventy-five per cent. of water, so that the solid matter thus evacuated is not above one or one and a half ounces. Of the degree in which the bile, as a whole, enters into the composition of the feces, it is difficult to speak with precision. Its coloring and its fatty matter are undoubtedly present, but scarcely any traces of choleic acid or of either of its conjugated compounds, or of their soda-base can be detected, so that the proper biliary matter must either have undergone decomposition, so as to be no longer recognizable, else it must have been reabsorbed. The latter is the idea now usually entertained, although Valentine has endeavored to show that the proper fœcal matter is chiefly derived from decomposed constituents of the bile. A more probable source for this, however, will presently be offered. The indications of the presence of bile are more distinct when the feces have remained for only a short time in the large intestines, and when there has consequently been less time for its reabsorption. In fœcal discharges which result from the action of mercurials, or other medicine which has a similar effect, large quantities of biliary matter may be detected very little changed. Although it can not be stated with certainty what is the precise amount of the glandular apparatus connected with the intestinal canal, which is concerned in the elimination of that peculiar putrescent matter which give the feces their characteristic odor, yet it may be stated almost with certainty that this matter is not derived from the decomposition of the undigested residue of the food, for, in the first place, this residue consists of matters

whose very inaptitude for undergoing chemical change is the source of their indigestibility; and it is scarcely possible, therefore, to imagine that in so short a period they should acquire a character so peculiarly offensive. But further, we observe that feces matter is still discharged, even in considerable quantities, and after the intestinal tube has been completely emptied of its alimentary contents. We see this in the course of many diseases, when food is not taken for several days, during which time the bowels have been completely emptied of their previous contents by repeated evacuations; and whatever then passes in addition to the biliary and pancreatic fluids, must be derived from the intestinal walls themselves. Sometimes a copious flux of putrescent matter continues to take place spontaneously, whilst it is often produced by the agency of purgative medicine. The colliquative diarrhœa which frequently comes on at the close of exhausting disease, and which usually precedes death by starvation, appears to depend not so much upon a disordered state of the intestinal glandula themselves as upon the general disintegration of the solids of the body, which calls them into extraordinory activity for the purpose of separating the decomposing matter which has accumulated in it to a most unusual amount. That if albuminous or gelatinous compounds be heated with solid hydrate of potash, and the heat be continued until the greater part of the whole of the nitrogen has been dissipated as ammonia, and hydrogen begins to be given off, the residue, when supersaturated with dilute sulphuric acid and distilled, yields a liquid containing acetic and butryic acids, and possesses in a very intense degree the peculiar and

characteristic odor of human feces. The odor varies according to the substance employed, and in this way all varieties of fœcal smell may be obtained. As the action of caustic potash at a high temperature is simply a limited or incomplete oxidation or combustion, this curious result confirms the view which had been previously put forth, that the proper fœcal matter is the product of the imperfect oxidation which a portion of histogenetic constituents of the food undergo in the course of their regressive metamorphosis, being comparable to the soot or lampblack of a furnace or lamp. It is further urged by him that the condition of feces differs in many particulars from that of substances in a state of fermentation or putrefaction, that their peculiar odor is entirely unlike any that is generated by the ordinary decomposition of organic compounds, whether azotized or non-azotized, and that by contact with air they themselves undergo a sort of fermentation or putrefaction in which their peculiar fetor disappears; a fact, as he justly remarks, which is full of significance. This view is of great practical importance, for if it be true that the intestinal canal receives and discharges the products of the secreting action of a glandular apparatus, whose special function is the elimination of certain products of decomposition from the blood, the facility with which we can stimulate this to an increased action by certain kinds of purgative medicines, gives us a most valuable means of augmenting its depurative action, seeing, as no medical practitioner can avoid doing, how frequently Nature herself employs this means of eliminating morbific matter from the intestines, as shown by the immense relief often given by an at-

tack of diarrhœa. We may look upon this apparatus as one which, like the liver or skin, or kidney and spleen, may frequently be stimulated by medicines that have a special action upon it, and through which some morbific matter may be got rid of more certainly and more speedily than through any other channel.

It is not intended by these observations to encourage the system of violent and indiscriminate purgation, but to show that purgatives, judiciously administered, often constitute our best means of eliminating injurious matters from the system.

We have passed in review all the secretory glands of the alimentary canal: the parotis, sublingual and submaxiliary, which secretes the saliva; the pancreatic glands, which secretes the pancreatic juice; the bile, secreted by the liver, next comes. The spleen, which is classed among the ductless glands by a great many physiologists, deserves more than a passing notice, on account of its size and obvious functional importance in the requirements of the system. The minute structure of the spleen has recently been made the subject of careful research by many excellent microscopic observers. The following is a summary of the most important points they may be considered to have determined: The fibrous coat in man is composed of white fibrous tissue, with an intermixture of yellow or elastic fibres. In many of the lower animals, however, it contains non-straited muscular fibres, composed of fusiform fibre cells. The trabicular tissue consists of fibrous bands and threads which arise from the inner surface of the fibrous envelope and form a network that extends through the entire

organ, becoming connected also with the fibrous sheaths of the vessels which penetrate it. These bands are partly muscular in the animals which have muscular fibres in the external envelope of the spleen, but elsewhere they are simply fibrous. The spaces left by their intersection, which are by no means regular, either as to form or size, are occupied by the spleenic corpuscles and spleenic parenchyma. In the trabeculæ of the human spleen, Prof. Kolliker has discovered some peculiar fusiform cells, round nuclei, which are probably to be considered as contractile cells, not developed into their properly characteristic form. The peculiar spleenic corpuscles are whitish spherical bodies, which are embeded in the spleenic parenchyma, but are connected with the smaller arteries by short peduncles like grapes with their fruit stalks, or are sessile upon their sheaths. Owing to the rapid changes which they undergo after death, and the influence of previous disease and abstinence, they are seldom observed in the human subject, but are best seen in the perfectly fresh spleens of the ruminatia. There is no doubt of their invariable presence in the healthy human subject, although this has been denied by many anatomists. The size of these corpuscles, when fully developed, varies from one sixth to one third of a line. Each of them consists of a delicate fibrous envelope, derived from the sheath of the artery to which it is attached, and frequently surrounded with capillaries of extreme minuteness. The remarkable discovery has recently been made by Dr. Sanders, that the interior of the malpighian corpuscles is traversed by arterial twigs of considerable size. Many observations of the author have shown

that there is a special connection between the malpighian corpuscles and the lymphatics of the spleen, but it may be considered as quite determined by the concurrence of the most recent observations on this point. The true spleenic parenchyma consists, in great part, of cells which correspond in appearance with those of malpighian corpuscles, and which are, like them, imbedded in a nearly homogenous plasma; but two other kind of cells occur in it which are seldom met with in the latter, and numerous free nuclei are also present. Of these two kinds of cells, one set is smaller and the other larger than the average of the parenchymatous cells; the former bears a strong resemblance to red corpuscles, but of a paler color. These elements, like the contents of the malpighian corpuscles, vary greatly in their proportion to each other, from which it may be concluded that they are in a state of continual development and degeneration. They do not lie collected in large heaps, but form small irregular groups of different sizes, which are clustered especially on the sheaths of the vessels, the trabecular partitions and the membranes of the malpighian corpuscles. They are not themselves included in special envelopes. Besides the usual corpuscles and granules of the parenchyma, it contains, dispersed through it in very inconstant amount, some remarkable colored particles, varying from the size of small granules to that of blood corpuscles, and often aggregated in masses of 1-1000 of an inch in diameter, having a distinct envelope which sometimes contains as many as twenty corpuscles. These are probably blood corpuscles in various stages of degeneration, but they are by no means peculiar to the

spleen, for they present themselves in many other situations, where extravasations of blood occasionally occur, and, as remarked by Dr. Sanders, from all the circumstances connected with them, they would appear to be the product, not of organic processes, but of physical alteration in stagnant blood, and are only more abundant in the spleen because more blood is retained after death in its pulp than in the substance of other organs. Of the spleenic arteries it is chiefly to be observed that their branches form no anastomoses, but that they subdivide and ramify like the branches of a tree with the malpighian corpuscles attached as fruit. Beyond their connection with these they enter into the red spleen substance, and here each twig subdivides into a tuft of arteries still more minute, which again subdivide into a close network in the spleenic pulp. Of the veins it is positively nothing peculiar in their distribution. The lymphatics of the spleen are few and inconsiderable in all, being less numerous than in other glandular organs, such as the liver and kidneys. The nerves of the spleen are very large in some animals, but the great size of their trunks and branches is chiefly due to the large proportion of ordinary fibrous tissue which enters them. That the ductless glands have some office of importance to perform in the preparation and maintenance of the blood, cannot any longer be reasonably questioned, and the determination of this point may be fairly regarded as a considerable step in the investigation. It is obvious, from the very copious supply of blood which they receive during the period of their functional vigor, and from the manner in which this is distributed by the glandular vessicles,

that it must be subservient to some process of active change; and the aspect of the contents of these vessicles as well as of the substance in which they are imbedded, indicates that cell-growth is rapidly proceeding at the expense of the materials thus afforded. But, on the other hand, that the products of this cell-growth are not substances which, like those of the ordinary glands, must be separated from the blood either for its purification or to serve some special purpose in the economy, appears from the fact that they are not carried off by ducts, but are received again into the current of the circulation. This would be equally true in the end were these products discharged by the lymphatics, but such an idea is inconsistent with our present knowledge of the distribution of these vessels; and it may be considered next to certain that the matters, whatever their nature may be, which have been elaborated by these glandular organs, are received again through the venous system; so that after having passed through the lungs they will be carried by the systemic arteries through the system at large; but the spleenic vein, it will be remembered, forms one of the roots of the portal trunk, and its blood must pass through the liver before it enters the vena-cava. Whatever materials then are withdrawn from the blood by the organs, are returned to it again in an altered state, and that the change which they have undergone is one that prepares them for higher uses in the economy, may fairly be inferred from the circumstances. For, as the blood which has received them is immediately transmitted to the system without having passed through any other depurating organ than the lungs, it appears fair to conclude that

the products which it has taken up in these organs are either combustic or nutritive, *i. e.*, either serve to maintain the functional activity of the lungs, or of the system, or of the blood itself. Now, that they are not destined to prepare a pabulum for respiration, appears from the very small quantity of fat which is found in their substance, except when their period of functual activity has gone by. On the other hand, the albuminous nature of the plasma, and the fine granular appearance which it presents, strongly indicate that a material is here in progress of preparation which is to be rendered subservient to the formative operations. The peculiar position of the spleen in reference to the portal circulation, however, seems to mark it out as having some special function of a supplemental character. Two out of the many theories of its action which have been advanced, deserve particular notice in connection with this point.

Many experimenters have come to the conclusion that, whatever may be the other purposes answered by the spleen, it serves as a diverticulum to the portal circulation, so as to relieve its vessels from undue turgescence, in virtue of the readiness with which it is distended with blood; and this, under a great variety of circumstances. As the portal system is destitute of valves, the spleenic vein has free communication with the whole of it, so that the spleen will serve as a receptacle for the venous blood when the secreting action of the liver is feeble, so that the portal circulation receives a partial check. That any cause of obstruction to the hepatic circulation peculiarly effects the spleen, has been proved by experiments; for after the vena portal had been tied, the

spleen of an animal which previously weighed only two ounces, has been found to weigh a pound and a quarter, or ten times as much. Further, it is evident that turgescence of the portal system is liable to occur when the alimentary canal is distended with food. It appears that the spleen has its maximum volume at the time when the process of chymifaction is at an end, namely: about five hours after food is taken, and that it is small and contains but little blood seven hours later, when no food has been taken in the interval. The spleen rapidly increases in bulk after the ingestion of a large quantity of fluid, which is absorbed rather by the vein than by the lacteals. It has been further stated in support of this theory, that animals from which the spleen has been removed are very liable to die of apoplexy if they take a large quantity of food at a time, but that if they eat moderately and frequently they do not suffer in this manner. Yet some physiologists say that the coats of the stomach secrete from seventy-five to eighty-five ounces in twenty-four hours. From what? Simply nothing.

The next great link in the chain of the animal economy is, what office does the spleen perform in the animal economy? *Do not know, comes the answer of the savants.* Now this important point I will endeavor to explain. Anatomists say there is a large artery passing into the spleen and divides into a network of small arteries, and, in fact, unites so closely that it appears that there is a continuous chain from the spleenic arteries directly into the spleenic veins and the blood; after it passes out by those veins the properties of blood are changed in a remarkable degree. Now this point has troubled me ever since

I read Bronsay's Principles of Physiology, when I was a boy, until after strict examination I found, after repeated trials, that there is a direct communication from the spleen to the coats of the stomach, and solved the great problem, the use of the spleen, and where that great amount of gastric juice comes from. My theory is as follows: The spleenic artery conveys the blood into the spleen, which manufactures the gastric juice direct from the blood, and conveys it by a large number of small arteries into the inner coats of the stomach; and those small follicles, or cells, or sacks, that are heretofore mentioned, are merely deputaries of the gastric juice. So that when food is received into the stomach it is there ready to answer the requirements of nature. The spleenic artery being so much larger than the arteries which pass into any of the other secretory glands, shows that Nature has wisely provided the means for an abundant supply of the gastric juice.

There has been many authors in different ages of the world who have made diligent search and enquiry to ascertain the source of the gastric juice, but failed to find it from the fact that they did not try in the right way; and, likewise, to find the use of the spleen, and failed in that for the same reasons. They were like the ruler who went to the prophet, who ordered him to bathe in the river Jordan; and he was not satisfied, but expected some great thing. And in my investigations I followed the example of others. I tried to inject the blood vessels of the spleen with alcohol, ether, etc., when the vessels were already cold and corrugated, which only corrugated them more; but I did not despair. I continued my investigations

on hogs, beeves and other different animals, and I found, after repeated experiments, that soon after death the blood vessels were less corrugated; and acting upon that hypothesis, I continued my investigations still further. I found I could inject the fluids much farther in the blood vessel when it was warm than when it was cold; and I found that warm water, at the temperature of 98° to 100°, was more easily injected than when it was colder; so after repeated trials, I killed a hog for pork, and I had a tub of warm water and an injecting apparatus in readiness, and as soon as my butcher took the entrails from the hog I had him deposit them in the tub of warm water, and had him cut the stomach open on the opposite side from the spleen, and I applied my injecting apparatus with warm water colored red. When the inner surface was laid open, I immediately saw that it was covered all over with an emenation of gastric juice, which collected in large drops and soon formed small streams, and as it continued to flow I soon discovered it was tinted with red, and finally it was as red as it was in the vessel from which it was taken, and equally as void of taste, which gave me conclusive proof that there is a direct communication between the vessels of the spleen and the coats of the stomach; and the gradual change in the conditions of it, from the time it began to flow until it ceased to flow from my injecting apparatus, showed to me that the spleen was the fountain source, and those follicles were the depositories, for upon examination of them after my experiment I found them empty.

Under the microscope the spleenic venous blood presented remarkable differences from the blood of

the general venous system, as represented by the blood of the jugular vein and from arterial blood. The red corpuscles did not form rouleaux, but in great numbers were aggregated in thick irregular heaps, or in smaller numbers forming little round or angular flakes. After some days this firm cohesion of the corpuscles diminished. The size of the corpuscles varied extremely, but the majority were very small; smaller, indeed, than the corpuscles found elsewhere. The white corpuscles were very numerous; in one case they amounted in number to a quarter or a third of the colored particles; they collected also in heaps, and seemed to be united by a fine molecular matter. In some places they were mixed up with the red particles. In size they varied greatly, being sometimes as large as a red particle; at other times double the size. Besides these there were cells constantly present, larger than the colorless corpuscles, and lay among them in heaps of two or three together; they were undoubtedly cells, and the cell wall could plainly be seen. They were always spherical, transparent, with a defined border, and contained from four to ten small, dark-outlined, strongly refracting granules, grouped in various ways, either centrally heaped together or forming a crescent, or without particular order, and frequently changing their mode of arrangement. It is apparent upon strict examination, that upon reception of food into the stomach the manufacture of the gastric fluid is the more rapid, and the displacement of the red particles of blood is separated, as before stated, and the serous portion is manufactured out of the blood and passes into the stomach, as before stated. When there is a deficiency of the

red particles of blood, or a deficiency of perchloride of iron in the blood, or when the spleen is inflamed and cannot separate the iron from the gastric secretion, the liver fulfills the office of the spleen; and again, when the liver becomes engorged and indurated, and cannot perform the two-fold office of gall and gastric juice, the pancreas eliminates from the dissolving property which the blood contains that is essential to dissolve the food. When this is the result a cerebral disturbance is manifested by a general atony of the system, a white fur upon the tongue, a weak, quick pulse, a grass-green discharge as the symptoms become more aggravated; a reaction takes place, fever sets in and relieves the sufferer by a collapse of the capiliary system. The remedies which will correct the secretions of the liver, spleen, salivary glands and pancreas, and create a general equilibrium in these secretions, will be given in my next issue. When the liver becomes inflamed a long train of symptoms is the result. Emaciated appearance of the face, drowsiness, jaundiced appearance of the skin, pain under the right shoulder blade, numbness in left arm between shoulder and elbow, and an increased appetite for animal food; the next symptoms will be thirst, yellowness of the eyes, a troublesome hacking cough, caused by increase in the size of the liver, pressing against the diaphragm and making the space too small for the lungs to expand and contract in inhalation and exhalation. These symptoms are followed by loss of appetite, furred tongue, chills, fever, and finally constipation of the bowels, followed by diarrhœa, clay-colored stools, general debility and death. So long as the alimentary matter remains in

the digestive cavity, however perfect may be its state of preparation, it is far from being conducive to the nutrition of the system as if it were in contact with the external surface. It is only when absorbed into the vessels and carried by the circulating current through the very substance of the body, that it becomes capable of being appropriated by its various tissues and organs.

Among the higher invertebrata, we find the reception of alimentary matter into the circulating system to be entirely accomplished through the medium of the blood vessels, which are distributed upon the walls of the digestive cavity. But in the vertebrata, we find an additional set of vessels interposed between the walls of the intestines and the sanguiferous system, for the purpose, as it would seem, of taking up certain components of the nutritive matter of which part, at least, are not in a state of perfect solution, and of preparing them for being introduced into the current of the blood. These are the absorbents of the intestinal walls of which those that are found after the performance of the digestive process to contain the white opalescent fluid known as chyle, are distinguished as lacteals, while the remainder, like the absorbents of the system generally, are known as lymphatics. The distinction is a purely artificial one, for the lacteals are the lymphatics of those parts of the intestinal walls which they supply, as is shown by the fact that during the intervals of the digestive process they contain a transparent fluid, in all respects similar to the lymphatics of the other parts. The absorbents form a minute plexus beneath the mucous lining of the alimentary canal along its whole extent,

but in the small intestines they enter the villi, at the extremities of which, indeed, they may be said to commence. Those only are entitled to the designation of lacteals which originate from the intestinal canal below the point at which the biliary and pancreatic ducts pour their contents into it; for above that point the fatty constituents of the alimentary matter are not in a state of sufficiently fine division to enter them, and the absorbed fluid is consequently pellucid instead of possessing the milky aspect. Thus, then, we are to consider the lacteal portion of the absorbent system to be that part of it which is especially adapted by its prolongation into the villi for the reception of an oleaginous fluid, which we shall presently see to be taken up from the contents of the alimentary canal, and to be prepared for entrance into the absorbents by a set of peculiar cells developed at the radical extremities of those organs. (For a general structure of the villi of the intestinal mucous membrane, see Carpenter's Human Physiology, sections 228–234.) But the peculiar disposition of their component structures must here be more minutely noticed. Each villus appears ordinarily to contain but a single lacteal tube, which occupies its center; in the larger villi, however, two or even more trunks are sometimes discernible. The mode in which this tube commences, near the extremity of the villus, has not yet been precisely made out; but it seems probable that it originates in a plexus formed by the anastomosis of branches into which it subdivides. This much, however, is quite certain, that the lacteals do not commence by orifices on the internal surface of the intestinal tube, as they were formerly supposed to

do. Each villus is also furnished with a minute plexus of capillary vessels, which lies near the surface. These sometimes pass between a single arterial and venous twig, as in the villus of the hare, but are sometimes supplied by several distinct twigs, as in the villi of man. The different arrangement of the vessels, the plexus differing in different animals.

In regard to the degree in which the function of nutritive absorption is performed by the lacteals and by the sanguiferous system respectively, considerable difference of opinion has prevailed. When the absorbent vessels were first discovered, and their functional importance was perceived, it was imagined that the introduction of alimentary fluid into the vascular system took place by them alone. A slight knowledge of comparative anatomy, however, might have sufficed to correct this error, since no lacteals exist in the invertebrated animals; the function of absorption being performed by their meseuteric blood vessels only; whence it is evident that these do possess the power of absorption; and it is scarcely to be supposed that they should not exercise this power in vertebrated animals also, since their disposition on the walls of the intestinal cavity is obviously favorable to it. On the other hand, the introduction of a new and distinct system of vessels would seem to indicate that they must have some special purpose; and there can be no doubt that the absorption of a particular kind of nutritive matter is that for which they are designed. That absorption is effected to a considerable amount by the agency of blood vessels, is shown by the readiness with which aqueous fluids, and even alcohol are taken up from the parietes of the stomach and are car-

ried into the general circulation. Thus, in a case of extroversion of the bladder, we may consider the sanguiferous vessels then as affording the usual channel by which a large part of the nutritive materials are introduced into the system; but these are not allowed to pass into the general current of the circulation until they have been subjected to an important assimilating process, which it appear to be one great office of the liver to perform, whereby they are rendered more fit for the purposes they are destined to serve in the economy. But the absorbing power which the blood vessels of the alimentary canal posseses are not limited to alimentary substances, for it is through them, almost exclusively, that soluble matters of every other description are received into the circulation. Absorption by the blood vessels is a simply physical operation, depending upon the relative consistency and miscibility of the blood and of the liquids to be absorbed, and upon the rapid movement of the blood through the vessels. Where the contents of the alimentary canal are of less specific gravity than the blood, and are capable of mingling with it, an endosmotic current will be established through the delicate parietes of the blood vessels, and then their investment between the two liquids, the former passing towards the other, and in this mode albuminous, gelatinous saccharine, saline and other soluble substances may be caused to enter the blood, if their solution be not too concentrated. But if their density be equal to that of the blood, or nearly so, little or no absorption is likely to take place, and one purpose, which is answered by the very copious discharge of aqueous fluid into the alimentary canal during the operation

of digestion, is obviously the reduction of the density of the solution to a favorable point. If, again, the density of the contents of the alimentary canal should exceed that of the blood, an endosmotic current might, perhaps, be established in the opposite direction, but their dilution would probably be effected so speedily that little of the contents of the blood vessels would be thus drawn forth, more especially as animal membranes appear to have a special power of resisting the passage of albumen, whilst they give free transmission to albuminose. That the movement of the blood in the vessels will vastly increase the rate of endosmotic absorption, is easily proved experimentally, and this it is which constitutes the main difference between the living and the dead subject.

The mucous membrane of the alimentary canal is by no means the only channel through which nutritive or other substances may be introduced into the circulating apparatus from external sources. The lymphatic system is present in all animals which have a lacteal system, and the two, as already pointed out, evidently constitute one set of vessels. The lymphatics, however, instead of commencing on the intestinal walls, are distributed through most of the vascular tissues of the body, and especially in the skin, but their number bears no proportion whatever to the vascularity of the several tissues, or to the amount of interstitial change which they undergo; and it is remarkable that the nervous centers should be entirely destitute of them, and that they belong rather to the connective areolar tissue than to the muscular substance itself. Their origin can not be clearly traced, but they seem in general to form a plexus in

the substance of the tissues, from which the convergent trunks arise, after passing, like the lacteals, through a series of glandular bodies. We find in the skin, also, a most copious distribution of capillary blood vessels, the arrangement of which is by no means unlike that of the blood vessels of the alimentary canal, and its surface is further extended by the elevations that form the sensory papillæ, which are in many points comparable to the intestinal villi, although their special function is so different. In the lowest tribes of animals, and in the earliest conditious of the higher, it would seem as if absorption by the external surface is almost equally important to the maintenance of life with that which takes place through the internal reflexion of it forming the walls of the digestive cavity. In the adult condition of most of the higher animals, however, the special function of the latter is so much exalted as usually to supersede the necessity of any other supply, and the function of the cutaneous and pulmonary surfaces may be considered as rather that of exhalation than absorption. But there are peculiar conditions of the system in which the imbibition of fluid through these surfaces is performed with great activity, supplying what would otherwise be a most important deficiency. It may take place either through the direct application of fluid to the surface, or even through the medium of the atmosphere, in which a greater or less proportion of watery vapor is usually dissolved. This absorption occurs most vigorously when the system has been drained of its fluid, either by an excess of the secretions or by a diminution of the regular supply. There appears no doubt that if the limb of a

person be placed in a liquid for a certain time, it will be full of the fluid through the means of imbibition or by absorption, and that there is a close correspondence in composition between the chyle of the lacteals and the lymph of the lymphatics; the chief difference being the presence of a considerable quantity of fatty matter in the former and of a larger proportion of the assimilable substances which are equally characteristic of both. This evident conformity in the nature of the fluid which these two sets of vessels transmit, joined to the fact that the fluid lymph, like the chyle, is conveyed into the general current of the circulation just before the blood is again transmitted to the system at large, almost inevitably leads to the inference that the lymph is like chyle, a nutritious fluid, and is not of an excrementitious character, as maintained by some physiologists. The close resemblance between the contents of the lymphatics and diluted liquor sanguinis, seems to indicate that the former are partly derived from the fluid portion of the blood which has transuded through the walls of the capillary vessels. And we shall presently see reason to believe that this transudation is partly for the purpose of subjecting the crude materials which may have been taken up direct into the blood vessels, to an elaborating or preparatory agency, such as it seems to be the special object of the lacteal system to exert upon the nutritive substances which it serves to introduce into the circulation. But it seems not impossible that there may be another source for the contents of the lymphatics. We have already had to allude, on several occasions, to the disintegration which is constantly taking place within the living body,

whether as a result of the limited duration of the life of its component parts, or as a consequence of the decomposing action of oxygen. It may be stated then, as a general proposition, that the function of the absorbent system is to take up and to convey into the circulating apparatus such substances as are capable of appropriation to the nutritive process, whether these substances be directly furnished by the external world, or be derived from the disintegration of the organism itself. We have seen in lacteals the selecting power is such that these vessels are not disposed to convey into the system any substances but such as are destined for this purpose, and that extraneous matters are absorbed in preference by the mesenteric blood vessels. The case is different with regard to lymphatics, for there is reason to believe that they are more disposed than the veins to the absorption of other soluble matters, especially when these are brought into relation with the skin, through which the lymphatic vessels are very profusely distributed. The alimentary substances taken up by the blood vessels and absorbents seem very far from being capable of immediate application to the nutrition of the body, for we find that they are not conveyed by any means directly into the circulating current, but those that enter the gastro-intestinal veins are submitted to the operation of the liver, whilst those that are received into the lacteals are subjected to a kind of glandular action wthiin their own system; the newly absorbed materials in both cases undergoing considerable changes, which tend to assimilate them to the components of the blood. It will be recollected that all the veins which return the blood from the ca-

pillaries of the gastro-intestinal canal, converge into the portal trunk, which distributes this blood charged with the newly absorbed materials, through the capillary system of the liver. The agency of this gland was formerly supposed to be limited to the elimination from the blood subjected to its influence of the materials of the biliary secretion, but there is now evidence that the blood itself is changed by its means in a manner which indicates an assimilating as well as depurating action. The blood which comes to the liver from the alimentary canal is charged with albuminous matter in a state different from that of the albumen of perfect blood, and the assimilation of this would appear from the observations of the most important functions of the liver. The saccharine matters are brought to the liver in the condition of grape sugar, or of cane sugar; are converted by its agency into liver sugar, a form of the saccharine principle of whose presence the blood is much more tolerant than it is of any other. From the saccharine componuds being brought to the liver, it appears that fatty matter can be generated; but as the introduction of this substance into the blood vessels ordinarily takes place through a different channel, the action of the liver would not appear to be essential to its assimilation, and it has been found that oil can be injected into the general circulation without exciting any violent effort at its elimination. The whole absorbent system may be looked upon as constituting one great alimentary gland. The circulation of nutritive fluid through the body has for its object, on the one part, to convey to every portion of the organism the materials for its growth and renovation, together with

the supply of oxygen which is requisite for its vital actions, especially those of the nervo-muscular apparatus, and at the same time to carry off the particles which are set free by the disintegration or waste of the tissues, and which are to be removed from the body by the excreting processes. Of these processes, the one most constantly in operation, as well as most necessary for the maintenance of the purity of the blood, is the extrication of carbonic acid through the respiratory organs, and this is made subservient to the introduction of oxygen into the system. In man, as in other vertebrated animals, there is a regular and continuous movement of the nutritive fluid through the sanguiferous vessels, and upon the maintenance of this the activity of all parts of the organism is dependent. In common with birds and mammals, again, man has a respiratory circulation entirely distinct from the systemic; all the blood which has returned from the body being transmitted to the lungs, and brought back to the heart again before it is again sent forth for nourishment of the tissues and for the maintenance of their functional activity. The heart is placed at the junction of these two distinct circulations, which may be likened to the figure 8, and it may be said to be formed by the fusion of two distinct organs—a pulmonary and a systemic heart; for its right and left sides, which are respectively appropriated to these purposes, have no direct communication with each other, and seem merely brought together for economy of material. Each system has its own set of arteries or efferent vessels, and of veins or efferent trunks. These communicate at their central ex remity by the heart, and at their peripheral

extremity by the capillary vessels, which are nothing else than the minutest ramifications of the two systems inosculating into a plexus, besides the systemic, although it has not an impelling organ of its own. This is the portal circulation, which is interspersed between the venous trunks of the abdominal viscera and vena cava, for the purpose of distributing that blood through the liver, in which organ its newly absorbed materials undergo assimilation, whilst its excrementitious matters are separated by the secreting process of the vena potaræ, which is formed by the convergence of the gastric, intestinal, spleenic and pancreatic veins, subdivides again like an artery, so as to form a capillary plexus, which extends through the whole substance of the liver and the hepatic vein, collecting the blood. This plexus conveys it into the vena cava. Thus the portal circulation is grafted upon the general circulation in precisely the same mode as the respiratory circulation is grafted upon it in mollusca and crustacea; and if the senus of vena portæ had possessed contractile muscular walls, it would have ranked as the proper heart of the portal system. The really arterial character of the vena portæ is well shown by comparing it with the aorta of fishes, which is formed by the convergence of the bronchial veins, and then distributes the blood which it has received from them to the blood generally. That the movement of the blood through the arterial trunks and the capillary tubes is, in man and in other warm-blooded animals, chiefly dependent upon the action of the heart, there can be no doubt whatever. It can be easily shown by experiment, that if the arterial current be checked, the capillaries will immedi-

ately cease, almost entirely, to deliver the blood into the veins, and the venous circulation will be instantaneously arrested. And it has also been proved that the usual force of the heart is sufficient to propel the blood not only through the arterial tubes, but through the capillaries into the veins; even a less force will serve to propel warm water through the vessels of an animal recently dead. But there are certain residual phenomena, even in man, which clearly indicate that it is not the whole truth, and that forces existing in the blood vessels themselves have a considerable influence in producing both local and general modifications of the effects of the heart's action. There are also indications of the existence of an influence in which the blood vessels do not partake, arising from those changes occurring between the blood and the tissues, that constitute the process of nutrition, secretion, etc. Such, for instance, would appear to be the interpretation of the fact that whilst any variations in the action of the heart effect the whole system alike, there are many variations in the circulation which, being very limited in their extent, cannot be attributed to such central disturbances, and must be dependent on causes purely local. Of the nature of these influences, and of the mode of their operation, the most correct idea may be obtained by examining the phenomena of the circulation in those beings in which the moving power is less concentrated than it is in higher animals; for we find that in plants, and the lowest animals, as in the earliest embryonic state of the higher, a movement of nutritious fluid takes place through a system of minute passages or channels excavated in the tissue, without any *vis a tergo*

derived from an impelling organ. Ascending a little higher in the series, we meet with a system of vascular trunks distributing the blood to these plexuses and collecting again from them, and the walls of these trunks are so far endowed with contractility as to assist, by a sort of peristaltic movement, in the maintenance of the current through them. Still passing upwards, we find this contracility manifesting itself especially in some limited portion or portions of the vascular system which execute regular movements of contraction and dilation, and this tendency to concentration is observed to increase until the whole movement is subordinated to the action of the principal propelling organ, the heart.

We shall now examine what agency in the human circulation may be attributed to the heart, the arteries and the veins respectively, and what other forces may be fairly presumed to operate in the capillary circulation. We do not purpose on entering in an anatomical description of the heart, or the action of the heart in health, further than a brief expression showing the connection with the digestive apparatus.

When the heart is exposed in a living animal and its movements are attentively watched, they are seen to follow each other with great regularity. In an active, vigorous state of circulation, they are so linked together that it is not easy to distinguish them into periods, both auricles contracting and dilating simultaneously, and both ventricles doing the same. Systole or contraction of the ventricles corresponds with the projection of the blood into the arteries, while the diastole or dilatation of the ventricles coincides with the collapse of the arteries. The contraction of the

ventricles and that of the auricles alternate with one another, each taking place during the dilatation of the other; but there is a period during which the auricles and ventricles of both sides are dilating together. This occurs during the first part of the ventricular diastole, for at the conclusion of the systole the auricles are far from being completely filled, and they go on receiving an additional supply from the veins until after the middle of the ventricular diastole, by which time they become fully distended and immediately contract. The contraction of the auricles is synchronous, therefore, with only the second stage of the ventricular disastole, and their dilatation is going on during the stage of the ventricular diastole and their dilatation is going on during the whole period of the ventricular systole. Thus, whilst the entire period that intervenes between one pulsation and another is nearly equally divided between the systole and diastole of the ventricles, the division is very unequal as regards the auricle, scarcely more than one eighth of the whole being occupied in their contraction and the remainder being taken up by their dilatation. The large veins near the heart contract simultaneously with the auricle and not whilst it is dilating, so that they can have no influence in causing its distension. The blood is expelled by the ventricular systole into the pulmonary artery, which it distends, passing freely through its semi-lunar valves, but as soon as this *vis a tergo* ceases and reflux might take place by the contraction of the arterial walls, the valves are filled out by the backward tendency of the blood and completely check the return of any portion of it into the ventricle. The blood, after having circulated through

the lungs, returns as arterial blood by the pulmonary veins to the left auricle, whence it passes through the mitral valve into the left ventricle and thence into the aorta through its semi-lunar valves, in the same manner with that on the other side, just described. The blood propelled from the heart is distributed to the body in general by a system of arteries which may be likened in its arrangement to the trunk and branches of a tree, except that very frequent communications or anastimosis exist among these branches, so that by continued subdivision and inasculation their distribution comes more to resemble the capillary network in which they terminate. Although the diameters of the branches at each subdivision together exceed that of the trunk, yet there is but little difference in their respectiveness. What difference does exist is usually in favor of the branches, and thus it happens that there is a gradual increase in the capacity of the arterial system from its center towards the capillaries, whose capacity is many times greater. There have been many theories written by physiologists of the passage of the blood through the capillaries, but one thing is certain: the blood does pass through, and with considerable regularity, and all the facts which bear upon the question of the connection between nervous agency and the forces maintaining the capillary circulation, have an equal relation to the functions of nutrition and secretion in general. The nervous system also influences these by the control it exerts over the diameter of the blood vessels. The venous system takes its origin in the small trunks that are formed by the reunion of the capillaries, and returns the blood from these to the heart. The

structure of the veins is essentially the same with that of the arteries, but the fibrous tissue of which their middle coat is made up bears more resemblance to the areolar tissue of the skin than it does to the true elastic tissue, and the muscular fibre-cells are usually much fewer in number and are sometimes wanting altogether. The elasticity of the veins is shown by the jet of blood which at first spouts out in ordinary venesection, when by means of the ligature a distension has been occasioned in the tubes below it. The movement of blood through the veins is effected by propulsive force. In several portions of the human body there are certain varieties in the distribution and in the functional actions of the blood vessels which should not be omitted in a general account of the circulation. Of these we have in the first place to notice the apparatus for the pulmonary circulation, the chief peculiarity of which is that veinous blood is sent from the heart through a tube which is arterial in structure, while arterial blood is returned to the heart through a vessel whose entire character is that of a vein. The movement of the blood through these is considerably affected by the physical state of the lungs themselves, being retarded by any causes which can occasion pressure on the vessels, and proceeding with the greatest energy and regularity when the respiratory movements are freely performed. The portal circulation, again, is peculiar in being a kind of offset from the general systemic circulation, and also in being destitute of valves; and it may be surmised, with much probability, that the purpose of their absence is to allow an unusually free passage of blood from one part of that system to an-

other during the very varying conditions to which it is subjected. Another very important modification of the circulating system is that which presents itself in the cranium. From the circumstances of the cranium being a closed cavity, which must be always filled with the same total amount of contents, the flow of blood through its vessels is attended with some peculiarities. The presence of the atmosphere is here exerted rather to keep the blood in the head than to force it out, and it may accordingly be inferred that while the quantity of cerebral matter remains the same, the amount of blood in the cranial vessels must also be invariable. This inference appears to derive support from the experiments of Dr. Kellie. On bleeding animals to death, he found that whilst the remainder of the body was completely exsanguine, the usual quantity of blood remained in the arteries and veins of the cranium; but that if an opening was made in the skull these vessels were then as completely emptied as the rest. It is not to be inferred that the quantity of blood within the cranium is not subject to variation, and that in the states of inflammation, congestion, or other morbid affections, there is only a disturbance of the usual balance of arterial and veinous circulation.

The nutritive fluid in its circulation through the capillaries of the system undergoes great alterations both in its physical constitution and in its vital properties. It gives up to the tissues, with which it is brought into contact, some of its most important elements, and at the same time it is made the vehicle of the removal from these tissues of ingredients which are no longer in the state of combination that fits

them for their offices in the animal economy. To separate these ingredients from the general current of the circulation, and to carry them out of the system, is the great object of the excretory organs, and it is very evident that the importance of their respective functions will vary with the amount of the ingredients which they have to separate, and with the deleterious influence which its retention would exert on the welfare of the system at large. Of all these injurious ingredients carbonic acid is, without doubt, the one most abundantly introduced into the nutritive fluid, and it is also most deleterious in its effects on the system if allowed to accumulate. We find, accordingly, that the provision for the removal of this substance from the blood is one of peculiar extent and importance, especially in the higher forms of animals; and further, that instead of being effected by an operation peculiarly vital in its performance, is secured by being made to depend upon simple physical conditions, and thus comparatively little susceptible of derangement from disorder of other processes. All that is requisite for it is the exposure of the blood to the influence of the atmospheric air through the medium of a membrane that shall permit the diffusion of gases; an interchange then taking place between the gaseous matters on the two sides, carbonic acid being exhaled from the blood and replaced by oxygen from the air. Thus the extrication of carbonic acid is effected in a manner that renders it subservient to the introduction of that element which is required for all the most active manifestations of vital power, and it is to these conjointly, not in either alone, that the function of respiration essentially consists.

We shall now inquire into the sources from which carbonic acid is produced in the living body, and causes of the demand for oxygen. The vital activity of the organism at large involve a continual change in its constituent parts, and those which live the fastest usually die the soonest and pass most readily into decay. Hence, in the very performance of the organic functions which concur to effect the nutrition of the body, there is a constant source of disintegration, and one of the chief products of the decay of the tissue, which is consequent upon their loss of vitality, is carbonic acid. Thus the most general object of the respiratory process, which is common to all forms of organized being, is the extraction of this principle of product from the system, and the demand for aeration hence arising will vary with the activity of the nutritive operations. Now the rate of life, and consequently the amount of disintegration, in any organized structure, depends in a great measure upon the temperature at which it is maintained, and thus it happens that the production of carbonic acid from this source at the ordinary rate of vital activity is much more rapid in warm blooded than in cold blooded animals, and that the former suffer far more speedily than the latter from the privation of air. But when the temperature of the reptile is raised by external heat to the level of that of the mammal, its need for respiration increases, owing to the augmented waste of its tissues. When, on the other hand, the warm blooded animal is reduced in the state of hibernation to the level of the cold blooded reptile, the waste of its tissues diminishes to such an extent as to require but a small exertion of the respiratory process to get rid

of the carbonic acid, which is one its chief products. And in those animals which are capable of retaining their vitality when they are frozen, or when their tissues are completely dried up, vital activity and disintegration are alike entirely suspended, and consequently there is no carbonic acid to set free. But another source of carbonic acid to be set free by the respiratory process, and one which is peculiar to animals, consists in the rapid changes which take place in muscular and nervous tissues in the very act of performing their peculiar functions; the development of the muscular and of the nervous forces involving, as the very condition of their production, a change in the substance of these tissues respectively, in which change a large quantity of oxygen is consumed and a large amount of carbonic acid is generated. Hence in man, as in all animals in which the nervo-muscular apparatus constitutes the essential part of the organism, a powerful demand for respiration is created by its activity, the amount of oxygen taken in and of carbonic acid exhaled being determined by the degree in which this apparatus is exercised. Besides these sources of carbonic acid, which are common to all animals, there is another which is restricted to the two highest classes, birds and mammals; these being distinguished by their power of maintaining a constantly elevated temperature. A part of this heat is generated by the oxygenation of the components of their disintegrating tissues, the metamorphosis of which takes place at a very rapid rate; but where this is not sufficient, their power of maintaining their temperature depends upon the direct combination of certain elements of the food with the oxgen of the

air by the combustive process. The quantity of carbonic acid that is generated directly from the elements of the food, seems to vary considerably in different animals and in different states of the same individual. In the carniverous tribes, which spend the greater part of their time in a state of activity, it is probable that the quantity which is generated by the waste or metamorphosis of the tissues, is sufficient for the maintenance of the required temperature, and that little or none of the carbonic acid set free in respiration, is derived from the direct combustion of the materials of the food. But in herbiverous animals of comparatively inert habits, the amount of metamorphosis of the tissues is far from being sufficient, and a large part of the food, consisting as it does of substances that cannot be applied to the nutrition of the tissues, is made to enter into direct combination with the oxygen of the air and to compensate for the deficiency. In man and other animals, which can sustain considerable variations of climate, and can adapt themselves to a great diversity of habits, the quantity of carbonic acid formed by the direct combustion of the elements of the food with the oxygen of the air, will differ extremely under different circumstances. It will serve as the complement of that which is formed in other ways, so that it will diminish with the increase and will increase with the diminution of muscular activity. It will also vary in an inverse ratio to the external temperature, increasing with its diminution and diminishing with its increase; the effect of external heat being thus precisely opposite in the warm blooded animals to that which it exerts on the cold blooded. In all cases, if a sufficient supply of

food be not furnished, the store of fat is drawn upon, and if this is exhausted the animal dies of cold. To recapitulate, then, the sources of carbonic acid in the animal body are three-fold: 1st. The continual decay of the tissues, common to all organized bodies, which is favored by all that promotes their vital activity and retarded by every influence that depresses it; 2d, the metamorphosis peculiar to the nervous and muscular tissues, which is the very condition of the production of their power, and which, therefore, bears a direct relation to the degree in which they are exerted; 3d, the direct conversion of the carbon and hydrogen of the food into carbonic acid and water, which is peculiar to warm blooded animals, and which varies in quantity in accordance with the amount of heat to be generated.

The wonderful nature of the structural arrangements which are made for the aeration of the blood n m an, and the completeness of the provisions whereby these are put into active operation, will be best understood if, for the sake of contrast, we first bestow a brief survey on the pulmonary apparatus. The following are the points of most importance in the structure of the human lung: The walls of the bronchial tubes contain distinct longitudinal and circular layers of fibrous structure, but the latter alone contain muscular fibre cells. These tubes divide and subdivide like the branches of a tree, still retaining their ordinary character, until they come to an abrupt termination. Beyond this boundary the tubular form of the air passages continued from the bronchi is retained for some distance, but it is gradually changed by the irregular branches of the passages

and by the increase of the number of apertures in their walls, which lead to the air-vesicles. Thus, at last, each minute division of the air passages become quite irregular in form, air-vesicles opening into every part of them, and almost constituting their walls, until they terminate almost without dilatation in an air-vesicle. This terminal portion of the air passage with its surrounding clusters of air-vesicles may be regarded as forming a sort of lobule. These vesicles which communicate directly with the bronchial tubes and intercellular passages open into them by large circular apertures, and they are themselves similarly opened into by other vesicles, which again communicate with others beyond them, so that each of the openings in the air passages leads to a series of air-vesicles extending from them to the surface of the lobule. The vesicles which communicate most directly with the air passages are more minute and have a closer network than those which lie nearer the surface of the lobule, an arrangement which is in beautiful harmony with the relative facility of renovation of the air which they respectively contain. It has been computed by some physiologists that there is not less than one half pound of air to each square inch of surface when the lungs have been filled by the deepest possible inspiration, so that the whole amount, reckoning on an average surface of 300 square inches for the male and 247 square inches for the female, will be not less than 150 pounds for the male and 123½ pounds for the female. This force is exerted in aid of the expiratory movement, and is directly antagonistic to the inspiratory, so that the inspiratory muscles must overcome it in order to pro-

duce complete distension of the pulmonary cavities. This distension is entirely accomplished by the action of the muscles external to the thorax or partly forming its parietes. The lung completely fills the cavity of the pleura in the healthful state, at lesst so that when this is enlarged a vacuum would be produced if it were not occupied by a corresponding enlargement of the lung; and to effect this the air rushes down the trachea and thence passes into the entire substance of the lung, which it fills out in every dimension. This distension is much more complete than any that could be occasioned by simple insufflation from the trachea, for long before internal pressure could overcome the resistance set up by the elasticity of the lungs, and still more by that of the parietes of the chest to the full dilatation of the air vessels, the tissues of the lung itself would be almost certain to give way. This has actually happened in numerous instances, and it constitutes a very forcible objection to the use of any apparatus for artificial respiration, whose action is that of insufflation. The complete dependence of the inspiration of the lungs upon the enlargement of the cavity of the chest, is well known by the effect of admission of air into the pleural cavity. When an aperture is made on either side, the air rushes in at each inspiration of the lung so that a sufficient amount of change takes place for the maintenance of life. It cannot be too strongly impressed upon the medical practitioner, and through him upon the public in general, that the continued respiration of an atmosphere charged in a far inferior degree with the exhalation from the lungs and skin, is among the most of all predisposing causes of disease, and

especially of those zymotic diseases whose propagation seems to depend upon the presence of fermentable matter in the blood. That such is really the fact will appear from evidence to be presently referred to, and it is not difficult to find a complete and satisfactory explanation of it; for as the presence of even a small percentage of carbonic acid in the respired air is sufficient to cause a serious diminution in the amount of carbonic acid thrown off and oxygen absorbed, it follows that those oxidizing processes which minister to the elimination of effete matter from the system must be imperfectly performed, and that an accumulation of substances tending to putresence must take place in the blood. Hence there will probably be a considerable increase in the amount of such matters in the pulmonary and cutaneous exhalation, and the unrenewed air will become charged not only with carbonic acid, but also with organic matter in a state of decomposition, and will thus favor the accumulation of both these morbific substances in the blood instead of effecting that constant and complete removal of them which it is one of the chief ends of the respiratory process to accomplish. It has been customary to consider the consequences of imperfect respiration as exerted merely in promoting an accumulation of carbonic acid in the system, and in thus depressing the vital powers and rendering it prone to the attacks of disease. But the deficiency of oxygenation and the consequent increase of putrescent matter in the body, must be admitted as at least a concurrent agency, and when it is borne in mind that the atmosphere in which a number of persons has been confined for some time becomes actually offensive

to the smell in consequence of the accumulation of such exhalations, and that this accumulation exerts precisely the same influence upon the spread of zymotic disease that is afforded by the diffusion of sewer-atmosphere through respired air, it scarcely admits of reasonable doubt that the pernicious effect of over-crowding is exerted yet more through its tendency to promote putrescence in the system than through the obstruction it creates in the due elimination of carbonic acid from the blood. For it is to be remembered, that whilst the complete oxidation of the effete matters will carry them off by the lungs in the form of carbonic acid and water, leaving urea and other highly azotized products to pass off by the kidneys, an imperfect oxidation will only convert them into those peculiarly offensive products which characterize the fæcal excretions.

Of the remarkable tendency of the respiration of an atmosphere charged with the emenations of the human body to favor the spread of zymotic diseases, a few characteristic examples will now be given. All those who have had the widest opportunities for studying the conditions which predispose to the invasion of cholera, are agreed that overcrowding is among the most potent of these, and the Report of the General Board of Health, on the late epidemic, contains numerous cases in which this was most evident, of which the following may be selected: In the Autumn of 1849, a violent attack of cholera occurred in the workhouse in the town of Staunton, England, where no cases of cholera had previously existed, and none subsequently presented itself among the inhabitants of the town in general, though diarrhœa

was prevalent to a considerable extent. The building was altogether badly constructed, and the ventilation deficient; but this was especially the case with the school rooms, there being but about 68 cubic feet of air for each girl, and even less for the boys. On November 3, one of the inmates was attacked with the disease; in ten minutes from the time of the seizure the sufferer passed into a state of hopeless collapse; within the space of forty-eight hours from the first attack, forty-two cases and nineteen deaths took place; and in the course of one week sixty of the inmates, or nearly 22 per cent. of the entire number, were carried off, whilst almost every one of the survivors suffered more or less severely from cholera or diarrhœa. Now in the jail of the same town, in which every prisoner is allowed from 819 to 935 cubic feet of air —and this being continually renewed by an efficient system of ventilation—there was not the slightest indication of epidemic influence. Also the penetentiary at Columbus, Ohio, in the epidemic of 1849.

Cholera is also produced by miasmatic influence, as demonstrated by the following cases: In the Spring of 1848 the author was living on Mill Creek, adjoining the city of Cincinnati, Ohio, and there was a pond drained into the creek; the weather was warm, and there was an unusual amount of Diarrhœa and an increased number of patients in the Commercial Hospital suffering from billious diarrhœa; the next week the cholera broke out to an alarming extent. In 1850, in Tuscarawas County, Ohio, there was a large pond opened into the Tuscarawas river, and the same disastrous results followed as at Cincinnati. Also in 1850, there was a large pond drained close to the

town of New Canton, Pike Co., Ill., and in ten days after the water was all let off about one half the people were afflicted with cholera and a large per cent. died.

The cholera epidemics here referred to as affording the most remarkable examples of the influence of a contaminated atmosphere in predisposing those habitually living in it to the invasion of zymotic disease, yet the evidence is not less strong in regard to the uniform prevalence of ordinary fevers, etc., in the same localities, the places in which cholera was the most severe having been almost invariably known as fever-nests at other periods, and being distinguished by a very high rate of mortality. Thus it appears that in all climates, and under all circumstances and conditions of life, the purity of the atmosphere habitually inspired is essential to the maintenance of that power of resisting disease which even more than the habitual state of health is a measure of the real vigor of the system. For owing to the extraordinary capability which the human body possesses of accommodating itself to circumstances, it not unfrequently happens that individuals continue for years to breathe a most unhealthy atmosphere without apparently suffering from it; and thus when they at last succumb to some epidemic disease, their death is attributed solely to the latter, the previous preparation of their bodies for the reception and development of the zymotic poison being altogether overlooked. It is impossible, however, for any one who carefully examines the evidence, to hesitate for a moment in the conclusion that the fatality of epidemics is almost invariably in precise proportion to the degree in which

an impure atmosphere has been habitually respired; that an atmosphere loaded with putrescent miasmata may afford a radius wherein a zymotic poison undergoes a marked increase in quantity and intensity, the putrescent exhalations from the lungs and skin of the living subject being at least as effectual in furnishing such a radius as are the emanations from fæcal discharges or from other decomposing matters. That the habitual respiration of such an atmosphere tends to induce a condition of the blood which renders it peculiarly susceptible of perversion by the introduction of zymotic poisons, and which favors their multiplication within the system; and lastly, that by due attention to the various means of promoting atmospheric purity, and especially to efficient ventilation and sewerage, the rate of mortality may be enormously decreased, the amount and severity of sickness lowered in at least an equal proportion, and the fatality of epidemics almost completely annihilated. And it can not be too strongly borne in mind that the efficacy of such preventive measures has been most fully substantiated in regard to many of the very diseases in which the curative power of medical treatment has seemed most doubtful, as for example in cholera and malignant fevers.

The function of nutrition considered in the widest acceptance of the term, includes the whole series of operations by which the alimentary materials prepared by the digestive process, introduced into the system by absorption, and carried into its penetralia by the circulation, are converted into organized tissues; but in a more limited sense, it may be understood as referring to the last of these operations only,

that of histogeneric or tissue-formation, to which all the other organic functions, in so far as they are concerned in maintaining the life of the individual, are subservient, by preparing and keeping in the requisite state of purity the materials at the expense of which it takes place. It has been shown that the formative capacity does not exist in the tissues alone, but it is shared by the blood, which must itself be regarded as deriving it from the original germ, for there are certain simple kinds of tissue which seem to take their origin directly in its plastic components. Of others, which can not be said thus to originate in the blood, the development is entirely determined by the quantity of their special pabula which it may contain. And even of those tissues which must be considered as most independent and self-sustaining, the development is not only checked by the want of a due supply of their appropriate materials, but it is modified in a very remarkable degree by the presence of abnormal substances in the blood, which single out particular parts and effect determinate alterations in their nutrition in such a constant manner as to show the existence of a peculiar elective affinity between them. In so far, then, as the process of nutrition is dependent upon the due supply and normal state of the blood, its conditions have already been sufficiently discussed, and we have now only to consider it in its relation to the tissues. The demand for nutrition primarily arises from the tendency of the organism to simple increase or growth. Of this we have the most characteristic illustration in multiplication of the first embryonic cell by the simple process of duplicative subdivision, whereby a multitude of cells is produced,

every one of which is similar in all essential particulars to the original. But after the different parts of this homogenous embryonic mass have taken upon themselves their respective modes of development, so as to generate a diversity of tissues and organs, each one of these continues to increase after its own plan, and thus the child becomes the adult with comparatively little change but that of growth. An excess of growth, taking place conformably to the normal plan of the tissue or organ, constitutes *hypertrophy*, whilst a diminution, without degeneration or alteration of structure, is properly distinguished as *atrophy*. but growth is not confined to the period of increase of the body generally, for it may manifest itself in particular organs or tissues as a normal operation at any subsequent part of llfe. Thus, when there is an extraordinary demand for the functual activity of a particular set of muscles, it is supplied by an increase in the amount of their contractile tissue; or, if one of the kidneys be disabled from performing its office, the other may be rendered capable of fulfilling it by augmented production of its own secretory tissue; or if there be an excess of fatty matters in the blood, they may be eliminated by an augmentation of the adipose tissue throughout the body. And further, even where there is no such manifestations of increase there is really a continual growth of all the tissues actively concerned in the vital operations, and this even to the very end of life, although it may be so far counterbalanced or even surpassed by changes of an opposite kind, that instead of augmentation in bulk there is absolute diminution. The evolution of the complete organism from its germ, however, does,

not consist in mere growth, for by such a process nothing would be produced but an enormous aggregation of simple cells, possessing little or no mutual dependence like those which constitute the shapeless masses of the algæ. In addition to increase there must be a development that is a passage to a higher condition, both of form and structure, so that the part in which this change takes place becomes fitted for some special function, and is advanced toward the state in which it exists in the highest or most completed of its specific type. Thus the development of tissue consists in the change from a simple mass of cells or fibres into another form, as in the production from the cellular substance of the tooth-pulp, or in the formation of bone in sub-periostal membrane. Again, the developmental change is seen in the passage of an entire organ from a lower to a higher condition by evolution of new parts, or by a change in the relations of those already existing, even though the change in its texture should consist of little else than of simple increase. Thus in the development of the heart, we have the original single cavity subdivided, first into two, and at last into four chambers; and in the development of the brain, we find the sensory ganglia to be the parts first formed, the anterior lobes of the cerebrum to be evolved from these, the middle lobes sprouting forth from the back of the anterior, and the posterior from the back of the middle, yet with all this there is no production of any new tissue; the new parts being generated at the expense of histological components identical with those of the pre-existing. Now it is in the early period of embryonic life that the developmental process

is most remarkably displayed, for it is then that we see that transformation of the primeval cells into tissues of various kinds, which originates a special *nisus* in each part, whereby the production of the same tissue in continuity with that first formed, comes to a simple act of growth, and it is then, also, that we observe that marking out of all the principal organs by the development of tissue in particular directions, which makes all subsequent evolution but a completion or filling up of the plan thus sketched out. Thus during the first few days of incubation in the chick, the foundation is laid of the vertebral column, the nervous centres, the organs of sense, the heart and circulating system, the alimentary canal, the respiratory apparatus and many other parts. At the termination of that period the chick emerges in such a state of completeness of development that little else than increase is wanting, save in the plumage and sexual organs, to raise it to its perfect type.

The same may be said of the human organism, save that the period of its development is relatively longer, in accordance with the higher grade which it is ultimately to attain; its earliest stages being passed through with rapidity. The completer evolution of the generative organs of the osseous skeleton and of the teeth, constitute the principal developmental changes which the human organism undergoes in its progress from the infantile to the adult condition; almost every other alteration consisting in simple increase in form or structure. And when the adult type has been once completely attained, every subsequent change is one rather of degeneration than of development—of retrogression rather than of advance.

The difference between the two processes of growth and development is most characteristically shown in those cases in which there is a partial or complete arrest of one of them, without any corresponding impairment of the other. The demand for nutrition arises not merely from the exercise of the formative powers, which are concerned in the building up of the organism, but also from the degeneration and decay which are continually taking place in almost every part of it, and the effects of which, if not antagonized, would speedily show themselves in the complete disintregation. We have seen that as each component cell of the organism has to a certain degree an independent life of its own, so has it also a limited duration, and that its duration bears an inverse ratio to its functional activity. This is particularly striking, when we compare the ratio of change in the organism of cold-blooded animals at low and at high temperature, for they live slowly, need little nutriment, give off but a small amount of excretory products, and require a long time for the performance of the reparative process under the former conditions; but they live fast, require a comparative large supply of nutriment, give off a far greater amount of carbonic acid and other compounds resulting from the waste of tissue, and exhibited a far more rapid reparation of injuries in the latter state. The constantly high temperature of man, as of other warm-blooded animals, prevents the difference from being displayed in him in a similar manner, but it will be seen, when we contrast his different tissues with each other, and study their respective histories. For whilst there are some which appear to pass through all their stages of

growth, maturiation and decline within a limited time, there are others whose existence seem capable of almost indefinite prolongation; and others, again, which are liable to have a period put to it at any time by the direction of their vital force into other channels. Of these, belonging to the first category, a characteristic example is presented by the overle, which, if not fertilized within a limited period after its maturiation, speedily declines and decays; and the same law of limited duration doubtless extends to a large proportion of such tissues as are actively concerned in the maintenance of the organic functions; as, for example, the corpuscles of the blood; the epithelial cells of mucous membrane, which minister to absorption in one situation and to secretion in another; the cells forming the parenchyma of the ductless glands, and many others. The contrary extreme to this may be found in those tissues whose functions are rather physical than vital, and especially in such as undergo consolidation by the deposit of solidifying matter, either in combination with the animal membrane or fibre, or in its interstices. Such tissues are withdrawn from the general current of vital action, and there seems to be no definite limit to their duration, except such as imposed by the chemical and mechanical degradation to which they are subjected. This appears to be the case with the simple fibrous tissue, especially the yellow, even in their soft or unconsolidated state; but it is far more obvious in the osseus substance, which is chiefly formed by the combination of calcareous salts with the fibrous animal basis. Again, in the dentine and enamel of teeth we have examples of tissues that have once undergone a sim-

ilar consolidation, retaining their condition unchanged through the whole remainder of life, under circumstances which show that if any nutritive change takes place in them its amount must be very small. Yet in both the osseous and dental structures of the young there is obviously a determinate limit of existence, as is shown in the rapid disappearance of a considerable part of the laellas, first formed in the cartilaginous matrix; also in the death and removal which continue to take in the inner and older portions of the shaft of a round bone during the whole period of its increase, and in the exuviation, at a certain epoch, of the first set of teeth, which exuviation is usually preceded by the death and disintegration of their own texture. In hair, nails and other epidermic appendages, which, when once their component cells have undergone consolidation by the deposit of horny matter in their interior, may remain unchanged for centuries, we must recognize the same principle of indefinite duration in connection with the annihilation of vital activity; the chemical constitution of these substances being such as renders them but little prone to be acted upon by ordinary decomposing agencies. In the case of the muscular and nervous tissues, we trace the operation of causes that differ from any of those already specified. These tissues are subject, like all others that are distinguished by their vital activity, to the law of limited duration; when not called into use they undergo a gradual disintregation, or wasting, which is not adequately repaired by the nutritive process. But their existence as living structures appears to be terminable at any time; the exercise of their functional powers for the development of muscular

contractility, or of nervous force, seems to invole as its necessary condition of the tissues, now reduced to the condition of dead matter, undergo those changes of blood towards the parts thus called into special activity. During the whole period of active life a demand for nutrition is created by every exertion of the vital powers, but more especially by evolution of the muscular and nervous forces. The production, and of these may be considered as the great end and aim of the human organism, so far at least as the individual is concerned, the whole apparatus of organic life being subservient to the building up and maintenance of the nervo-muscular apparatus and of those parts, the bones, cartilages, fibrous textures, &c., of all the parts which minister to the former, will be in proportion to the energy with which they are called upon. Of the mode in which the substitution of new tissue for that which has become effete is effected in process of nutrition, our knowledge is at present limited. There can be little doubt that it nearly always takes place in a manner closely conformable to the first development of each tissue, whose term of life has expired, or whose vital energy has been exhausted, are removed and disposed of, our present knowledge is no less imperfect. In the case of those tissues which are superficially nourished, a continual loss of substance is obviously taking place by the exuviation of dead particles *en masse;* this is the case with the whole series of epithelial and epidermic cells, which are thrown off with little previous change, like the leaves of trees, their decay not taking place for the most part until after they have become detached from the organism. But the fact is

altogether different with regard to those whose nutrition is instertial, especially the nervous and muscular tissues, for the decomposition of these would seem to occur in their substance, its products being taken up by the blood and subsequently eliminated from it by organs appropriated to that purpose. The evidence of this is seen, as regards muscle, in the presence of creatine, creatinine, inolite, and other undoubted products of regressive metamorphosis in the juice of flesh. As regards the nervous substance, no such definite proof can be at present afforded, since its normal constitution has not yet been sufficiently studied to enable the products of its decomposition to be distinguished. There is one remarkable form of disintregation which is common to nearly all the tissues, and seems to occur as a normal alteration in many of them at an advanced period of life. This consists in the conversion of their albuminous or gelatinous materials into fat, thus constituting what is known as fatty degeneration. That this change is not due to the removal of the normal components of the tissues and the substitution of fatty matter in their place, but is the result of a real conversion of the one class of substances into the other, has been already pointed out; and there are certain facts which indicate that this kind of degeneration is a part of the regular series of processes by which tissues that have served their purpose in the economy are prepared for being removed by absorption. In the case of the teeth—for the fangs of the deciduous teeth undergo degeneration—when the current of nutrition is diverted towards those which are to succeed them, their materials being slowly decomposed so as to be-

come soluble, and being gradually removed by absorption, nothing is left, at last, but the crown of the teeth. On the other hand, the permanent teeth, which are not to be succeeded by others, when no longer receiving their due nutrition, die and are cast out entire.

Among the conditions of healthy nutrition a due supply of nervous power is commonly enumerated, and it can not be questioued that the want of such a supply is frequently the source of a perversion of the normal operations. This by no means proves that the formative power is derived from the nervous system, and such an idea is at once negatived by a number of incontestable facts; yet it may be freely admitted that the right direction and application of this power in nutrition may sometimes depend upon guidance and direction afforded by the nervous centres, in the same manner as the secreting process is capable of being thus influenced. We can scarcely explain in any other mode that influence of mental states upon the nutrient operations.

Reparative Process.—The nutritive operations take place with extraordinary energy and rapidity in the process of reparation, by which losses of substance occasioned by injury or disease are made good. In its most perfect form, this process is exactly analagous to that of the first development of the corresponding parts, and its results are as complete in the one case as in the other. In man, in the place of what is lost by accident or disease, some lowly organized tissue is formed, which fills up the breach and suffices for the maintenance of a less perfect life. Even thus restricted, the operations of this power are frequently

most remarkable, and are in no instance, perhaps, more strikingly displayed than in reformation and remodeling of an entire bone, when the original one has been destroyed by disease. That this power is intimately related to that by which the organism is normally built up and maintained, is evident, not merely from the peculiar mode in which it is exercised, its tendency being always to reproduce each part in the form and structure characteristic of it at the particular period of life, and not according to its embryonic type, but also from the fact that it is more effectual in the state of growth than in the adult condition, and that it can do far more in the embryonic state, when development as well as growth is taking place, than after the developmental process has ceased. Thus it is well known to every practitioner how more readily and perfectly the lesions resulting from accident or disease are repaired in childhood and youth than they are after the attainment of the adult state. Small wounds in persons of good habits of body, and in parts which can be completely kept at rest, readily heal; and large wounds have been known to close in the same desirable mode beneath a clot of inspissated blood. That to induce the most favorable method, the most perfect freedom from all pernicious agencies should be required.

Of the alterations in the conditions of the blood in inflammation, the most characteristic is the augmentation, either of the organizable or plastic fibrine, or of the organized colorless corpuscles; the increased production of these two components seeming to bear in some degree a relation of reciprocity, the one to the other. The increase of fibrine may be considered

as the alteration most characteristic of a previously healthy and vigorous state of the system, and it is in the inflammations which occur iu such subjects that the effusions are most strongly disposed to become organized, and show the least tendency to undergo degenerative changes. On the other hand, the increase of the corpuscular element seems to occur in cachectic or otherwise unhealthy individuals, and the inflammatory effusions which partake of the same character, are far less plastic, originally, and are extremely prone to undergo degeneration, either at the time of their effusion, or subsequently. With this increase in the proportion of fibrine and colorless corpuscles separately, or in combination, there is a diminution in the proportion of the red corpuscles, albumen and salts of the blood. None of these changes, however, can be legitimately regarded as originally or essentially characteristic of the inflammatory condition; they are, in fact, to be looked on rather as the results of its establishment. Constituting that series of alterations in the circulating fluid which is of parallel order to that which occurs in the solid tissues, wherein the inflammatory action has been set up, the inflammatory state is further characterized by the effusion of certain of the components of the blood, upon the surface or into the substance of the inflamed tissues. The effusion of pure serum cannot be regarded as characteristic of inflammation, since it may take place as a mere result of congestion, especially when this congestion is due to an obstruction to the return of the blood; whilst again it may be due to an altered condition of the albuminous constituents of the blood which favors its transudation. The so-called

serous effusions, which are poured forth in inflammation, do, in reality, contain fibrine in solution, but this fibrine may not manifest its presence by spontaneous coagulation, until its passage into the solid state is favored by some extraneous influence. The presence of fibrine in such an effusion is not in itself a sufficient proof of the existence of inflammation, for it has been shown by experiment that when the obstruction to the return of blood by the veins is so great as to occasion an excessive pressure within the capillaries, the fluid which transudes may contain enough fibrine to render it spontaneously coagulable. The form of equdation which is most characteristic of inflammation is that which is known as coagulable lymph. It is much to be desired that some other designation should be applied to it, since the term lymph can only be applied to fluid contents of the lymphatic vessels. The peculiar characteristic of this inflammatory exudation, is its capability of spontaneously passing into the condition of an organized tissue, either fibrous or cellular, or a mixture of both, and thus forming false membranes or inflamed surfaces, or solidifying the inflamed part by the intestinal production of similar lowly organized textures. The condition of the blood as determining that of the characters of inflammatory deposits in different diathesis, correspond very generally and closely with those of the coagula found in the heart and pulmonary vessels after death. Chemical observations fully confirm this doctrine by evidence of another kind, that which is afforded by the different source of the same specific disease in different individuals, according to the previously healthy or abnormal condition

of the blood. There can be no doubt that a very large proportion of what are called virus, especially those of the erysipelatous type, are to be regarded as owing their peculiarity to a deficiency in the due elaboration of the fibrine, and to the low vitality of the cellular components of the blood, both of which conditions seems to be favored by the presence of those decomposing matters whose accumulation in the blood acts in many ways so prejudicially on the system at large. That the equality of the exudation is in some degree determined by the seat of tissue in which the inflammation occurs, appears from the different character of the product of the disordered action occurring simultaneously in different organs of the same individual, and apparently under the operation of the same cause. Thus it may happen that in pleuro-pneumonia the two surfaces of the pleura become connected by an organized exudation of a fibrous character, whilst the effusion in the substance of the lung is rather of the corpuscular nature, and speedily passes into supurative degeneration. The mode in which the intensity of the inflammation effects the character of the effused lymph, is two-fold. For in the first place the nature of the original effusion is likely to vary according to the degree in which the ordinary nutritive process is interpreted, since the more intense the inflammation, the less will be the assimilating force of the part, and the more will the matters effused from the vessels deviate from the natural plasma which would be drawn from them in healthy nutrition; whilst on the other hand, when the inflammation is less severe, its product will not differ so widely from the natural one, and will, from the first,

tend to manifest in its development some characters corresponding to those of the natural formations of the part. Various kinds of degeneration may take place, according to the stage at which the developmental process is checked, and among these in tissues which have once attained an advanced stage of development. The most common is the fatty. In persons of that peculiar constitution which is termed scrofulas, or strumous, we find an imperfectly organizable or caco-plastic deposit, or even an altogether plastic product, known by the designation of tubercular matter, frequently taking the place of the normal elements of tissues, both in ordinary process of nutrition, and still more when inflammation is set up. From an examination of the blood of tuberculous subjects, it appears that although the bulk of the coagulum obtained does not consist of well elaborated fibrine, for it is soft and loose, and contains an unusually large number ot colorless corpuscles, whilst the red corpuscles bears an unusually small proportion to it; hence persons of a strumous diathesis, in their diet, should keep in view this fact: that their system requires such food as will produce the greatest amount of iron in the blood. Tubercle is to be considered whose production is dependent upon a special taint in the blood; and just as the normal lymph products vary greatly in their degree of vitality, so that some undergo a progressive and others a retrograde metamorphosis, so may tubercular deposits either retain their original characters more or less completely, or may undergo a very early and complete degeneration. Now although tubercular matter may be slowly and insidiously deposited by a kind of degenera-

tion of the ordinary nutritive process, yet it can not be doubted that inflamation has a great tendency to favor it, so that a large quantity may be produced in the lungs after pneumonia has existed for a day or two, that it would have required years to generate in the previous mode. But the character of the deposit still remains the same, and its relation to the plastic element of the blood is shown by the interesting fact of no unfrequent occurrence, that in pneumonia, affecting a tuberculous subject, plastic lymph is often thrown out.

The ordinary process of nutrition involve a separation of certain of the components of the blood, which are withdrawn from it by the appropriating power of the solid textures, and every such removal may be considered in the light of an act of excretion, so far as the blood and the rest of the organism is concerned. The separation of certain matters from the blood in a fluid state, either for the purpose of being cast forth from the body, or of being employed for some special purpose within it, which constitutes what is known as secretion, is effected by an agency of the same nature with that whose operation constitutes the essential part of the nutritive process, namely, the production of the growth cells. Hence there is no other fundamental difference between the two processes than such as arises out of the diverse destinations of the separated matters and the anatomical arrangements which respectively minister to these. For the products of the secreting action are all poured forth either upon the external surface of the body, or upon the lining of some of the cavities which communicate with it, and the cells

by which they are separated from the blood usually stand in the relation of epethelium cells to those prolongations of the skin or mucous membranes that form either the projecting fringes, or the follicles or extended tubuli of which the glandular organs are, for the most part, composed, and are thus readily thrown off from their free surfaces. Thus the act of secretion essentially consists in successive production and exuviation of the cells which minister to it; these cells giving up by rupture, or deliquescence, the substance which they have eliminated from the blood. Each group of cells is adapted to separate a product of some peculiar kind, which constitutes its special pabulum, and the rate of its production seems to depend upon the amount of that pabulum supplied by the circulating fluid. The substances, at the expense of which the secreting cells grow, may not be precisely those which are subsequently cast forth at their death, for it is very probable that some of them at least undergo a certain degree of chemical transforformation by the agency of these cells; the characteristic materials of the several secretions not always pre-existing as such in the blood, a distinction may be drawn as regards this point, between those secretions, the retention of whose materials in the blood would be positively injurious, and those secretions which are destined for particular purposes within the system, and the cessation of which has no immediate influence on any other function than those for which they are respectively destined. The solid matter dissolved in the fluids of the latter class, is little else than a portion of the nutritive constituents of the blood, either so little altered as still to retain its nutritive

character, as is the case with the casein of milk, and with the albuminous constituents of serous fluid of areolar tissue, and of serous and synovial membranes, or in a state of incipient retrograde metamorphosis, as seems to be the case with the peculiar ferments of the salivary, gastric, pancreatic and intestinal secretions. On the other hand, the characteristic ingredients of the excretions are very different in character from the normal elements of the blood. They are all of them completely unorganizable, and they possess, for the most part, a simple atomic constitution. Some of them, also, have a tendency to assume a crystaline form, which is considered to indicate their unfitness to enter the composition of organized tissues. With regard to some of the chief of these, there is sufficient evidence of their existence in small quantity in the circulating blood; it is also clear that they exist there as products of decomposition, and that they are destined to be speedily as possible. If their separation be prevented, they accumulate and communicate to the circulating fluid a positive deleterious character. Of this we have a striking example in asphyxia, and the history of the other three principals of excretions, the spleen, liver and kidneys, will furnish evidence to the same effect. As a general fact, then, it may be stated that the materials of the secretions pre-exist in the blood in a state nearly resembling that in which they are thrown off by the secreting organs; but that the materials of those secretions which are destined to perform some particular function within the economy, are derived from the substances which are appropriated to its general purposes, whilst those of the excretions are the result

of the destructive changes that have taken place in the system and cannot be retained in it without injury.

The composition and uses of the principal secretions which are elaborated for special purposes within the economy, have already been partly described in connection with the function to which they respectively minister, and the remainder will hereafter come under notice in the same manner. It is here intended to consider that important system of excretory operations, which serves to maintain the purity of the circulating fluid, by removing from it those products of the disintregation of the tissues which are not capable of serving any purpose in the nutrition of the system, and which even act upon it as poisons; and also by withdrawing the products of the decomposition of those surplus alimentary materials, which, not being required for the nutrition of the tissues, undergo a retrograde metamorphosis without having ever undergone the process of organization. The process of respiration, as already pointed out, is in part to be regarded as one of an excretory character, though the peculiar manner in which it ministers to the removal of carbon and hydrogen from the system, and its subserviency to other purposes, necessitates its separate consideration. The true secreting processes which are to be regarded as more or less completely excretory, are the separation of the gastric juice from the spleen, of bile from the liver, that of urine by the kidneys, that of perspiration by the skin, and that of fœcal by the intestines. The sum total of these, with the addition of the carbonic acid and watery vapor poured from the lungs, and of the indigestable matter rejected in the form of feces, must be equal to the

total amount of solid and fluid ingesta and of the oxygen which disappears from the inspired air, the weight of the body remaining the same.

Under ordinary circumstances, the several parts of excretory apparatus are limited each to its own special function; yet we see that there are certain complimentary relations between them, which makes the action of one to a certain extent vicarious with that of another. Such a relation exists between the spleen, liver and pancreas, on the one side, and the lungs on the other side, for the more active the respiration, the less active are the other secretory organs; whilst if the respiration be lowered, a large proportion of unoxidized, or imperfectly oxidized, excrementitious matters accumulate in the blood, giving rise to that augmented production both of the biliary and fœcal secretions. The skin actually assists in the elimination of one of those azotized tissues, the removal of which has been, until recently, considered as the special function of the kidney. Consequently, whenever the due action of the skin as an excreting organ is interferred with, it is the kidney especially that will be called on to take its place; whilst on the other hand, if it be thought necessary to relieve the kidney, this may be most effectually done by stimulating the skin to increased excretory activity. The kidneys can not be regarded to be inferior to any of the excreting organs, but their function, also, consists in separating from the blood certain effete substances, which are to be thrown off from it, and has no direct connection with any of the nutritive operations concerned in the introduction of aliment into the system. The following are the points in the minute structure of these

organs, which are of most importance in their physiological relations: The distinction between the certicle and medulary parts of the kidneys, consists in this: that the former is by far the most vascular, and the plexus formed by the tubuli uriniferi seems to come into the closest relation with that of the sanguiferous capillaries, so that it is probably the seat of the greater part of the process of secretion; whilst the latter is principally composed of tubes passing in a straight line from the former towards their point of entrance into the uretor.

The circulation of blood through the kidneys presents a very remarkable peculiarity. The supply is derived in man direct from the arterial system. But although this organ is supplied from the venal artery, yet it is not to its proper secretory apparatus that the blood of that artery is distributed in the first instance, for on entering the kidneys this vessel speedily and entirely divides itself into minute twigs, which are the afferent vessels of the malpigian tufts. After it has pierced the capsule each twig dilates and suddenly divides and subdivides itself into several minute branches, terminating in convoluted capillaries, which are collected in the form of a ball, and from the interior of the ball the solitary afferent vessel arises, which passes out of the capsule by the side of the single afferent vessel.

The kidneys serve as the special instruments for depurating the blood of those highly azotized compounds, which are formed in the system by the decomposition of the materials of the albuminous and gelatinous tissues, and also by that of the non-assimilated components of the food. We have seen, also,

that they serve for the removal of certain compounds, of which carbon is a principal ingredient, and these, normally present in but small amount, may undergo a marked increase in disease, especially when the liver or spleen is insufficiently performing their functions, or the respiratory process is obstructed. We have been led to regard the kidneys as the emunctory, not only for the superfluous water of the system but also for those saline compounds which, having been introduced into the system or generated within it in larger amount than is compatible with the normal constitution of the blood, or than is required for the reparation of the solids of the body, or for the production of its fluid secretion, are only fitted for elimination. Those soluble salts are most readily excreted which produce a determination towards the kidneys, whereby an increased quantity of liquid is filtered off through the outlet they afford. And it is in the same way that the system makes an effort to free itself from various foreign substances which have been introduced into it by absorption, and which would be injurious if retained; the rate at which it does so being in a great degree dependent upon the functional activity of the kidneys. It does not appear that the excretion of the organic compounds which are formed within the system is augmented by those diuretic medicines which, by determining an increased flow of blood to the kidneys, cause a large amount of liquid to be passed off through them. On the contrary, it would seem as if by producing congestion and inanition, they sometimes interfered with the normal process of secretion.

In the discussion of the liver I shall not attempt an

anatomical description, further than to state that the hepatic artery sends branches to every part of the liver, supplying the walls of the portal and hepatic veins, and of the hepatic ducts. The hepatic duct forms, by its subdivision and ramification, an interlobular plexus, very like that of the portal vein. The conditions under which the secretion of bile takes place, and one of the most important of these is the character of the blood with which the organ is supplied, it exercises a depurative as well as an assimilating power over these; and whilst it assists in preparing for nutrition those azotized substances which are capable of being applied to that purpose, and also transform non-azotized matters into compounds, which are more ready to undergo combustion, and are thus better fitted for sustaining the heat of the body by respiration, it also eliminates certain substances whose passage into the general circulation would be injurious. The greater part of the bile which passes into the intestinal canal is ordinarily destined for reabsorption; it seems fair to conclude that the matters which accumulate in the blood, when the secreting action of the liver is suspended, are not in the same condition with those which are received back into it after being submitted to that action, and that the liver not only separates them, but exercises a certain transforming agency upon them, it is known to effect upon other constiuent of the blood which pass through it. Bile is a viscid, somewhat oily looking liquid, of a greenish-yellow color, and very bitter taste, followed by a sweetish after-taste; it is readily miscible with water, and its solution froths like soap.

The liver is an organ of excretion, designed to re-

move from the blood those hydro-carbonaceous products of the disintregation of the tissues, which can not be converted into sugar or fat so as to be prepared for direct elimination by respiratory organs. That in so doing this it converts those excrementitious matters into glycoholic and taurocholic acids, substances which have a certain utility in the digestive process, and which, after ministering to that function are capable of being re-absorbed and undergoing oxidation, whereby the greater part of their components are carried off in the form of carbonic acid and water by the lungs, the remainder being eliminated by the kidneys. That not only by the separation of biliary matter from the blood, and by the operation of this upon the alimentary substances, but also by the change in the constituents of the blood itself, the liver aids in preparing materials for the combustive process. For it converts all forms of saccharine substances derived from food into liver sugar, the form which is most favorable to oxidation, and it would seem capable also of generating this sugar from protein compounds, or from certain products of their decomposition, and it exercises a similar transforming power upon fatty matter, generating the peculiar liver fat either from other oleagenous, or from saccharine substances supplied by the food; or, as it would also appear, from protein compounds, or from the products of the early stages of their retrograde metamorphosis. In all the foregoing actions the liver is subservient to the respiratory function, but in a mode very different from that formerly believed. It is quite certain that if the whole of the solid biliary matter poured into the intestines were re-absorbed, it

could furnish but a small proportion of the total amount of hydro-carbon eliminated by the lungs and the other excreting organs.

The most important organ interested in the digestion of alimentary substances, and the greatest organ to disintregate from the blood, is the spleen, as we have before mentioned. We may not give our views as plainly and scientifically as it will be treated at some future time, bnt we think that we may be able to bring before the medical world that which will be a great benefit to the human family at large. The simple structure of the spleen, as we before said, separates the serous from the resamentum portion of the blood. When the spleen becomes inflamed, and the grape-like appendages of the arteries are congested with cacen from the blood, there will be a surplus of the blood highly charged with gastratin in the vena patarum, and the hepatic artery, and become assimilated by the liver into bile, and then pass into the general circulation, until the system is surcharged with bile and jaundice is the result. . On the other hand, when the liver becomes inflamed from ulcers or injuries by accident, or otherwise, and does not secrete a sufficient amount of bile to assimilate the chyme in the duodenum, then Nature makes a demand upon the spleen and pancreas; and if the spleen is inflamed and can not perform the office of the liver, in addition to that it already has to perform, then the pancreas is over-taxed, and has to perform the office of the liver and of the spleen, and the liver and chyle is highly charged with carbon. The next demand is made upon the skin, lungs and kidneys; if .they fail to restore the equilibrium, then inflammatory rheumatism is the result.

The next point we shall notice is the skin, which is the seat of various secretions, each of which is provided with special organs; the only one which can be regarded as truly excrementitious, is the transpiration of aqueous fluid holding certain matters in solution.

The elimination of this fluid from the blood is effected by the sudoriparous glandula, which, seated rather beneath than in the cutis, are diffused in varying proportions over the entire surface of the body. Of the whole fluid which passes off by the skin, only a small portion can properly said to be secreted by these glands, a large part, as in the case of the kidneys, being the product of simple transudation. It will be this part which will undergo augmentation when a special determination of blood to the skin is produced by external causes; and there is no more reason to think that an increase in the amount of solid matter thus excreted is induced by such agency, than that an increase in the solids of the urine can be determined by ordinary diuretics. Hence the debilitating effects commonly assigned to profuse perspiration must be attributed to some other causes, and these it does not seem difficult to find. Thus the great fatigue which is experienced as a consequence of muscular exertion in a heated atmosphere, may fairly be set down to the diminished activity of the respiratory process at high temperature, and the colliquitive sweating of hectic fever is obviously not a cause but a consequence of the debilitated state of the general system. The entire amount of fluid which is insensibly lost from the cutaneous and pulmonary surfaces, is estimated at 18 grains per minute, of which 11 grains pass off by the skin and 7 by the lungs. The maximum loss by exhalation, cutaneous and pulmonary during twenty-four hours, is 5 pounds; the minimum, 2 pounds; it varies according to the condition of the atmosphere. The whole amount of cutaneous transpiration, sensible and insensible, is greatly increased by heat and dryness of the surrounding air; the heat occasions a determination of an augmented amount of blood to the cutaneous vessels, and of the fluid which transudes a large portion is carried off in the state of vapor. The cutaneous excretion is in a great degree vicarious with the urine, in regard to the amount of fluid

eliminated. The share the skin has in the office has probably been generally underrated. There is reason to believe that at least 100 grains of azotized matter are excreted from it daily, and any cause which checks this excretion must throw an additional labor upon the kidneys, and will be likely to produce disorder of their function. The secretion of the skin is influenced by general conditions of the vascular and nervous systems, which are, as yet, not fully understood. It is quite certain that through the influence of the latter the secretion may be increased or depressed by external causes having a tendency to produce congestion and inflammation of internal organs; a partial suppression often gives rise to febline symptoms in man, and the decomposition of organic matter in the blood, which it is its special office to eliminate. Hence the due maintenance of health requires that the excretions should be promoted by the use of all natural means; if the kidneys are in active order, the natural result should be to stimulate the skin; if the lungs appear to be inflamed, increase the action of the skin and kidneys; if the paroted, sublingual or submaxillary glands are inflamed, stimulate the spleen; if the spleen is inflamed, stimulate the liver and pancreas, and *vice versa* when any organ is incapacitated from performing its especial office in the animal economy, stimulate the other organs which will relieve the organ affected, by performing the same office to a certain extent.

In my next issue I will introduce the therapeutical agents, with which the author has been the most successful after an experience of over thirty years' practice. That the reader may find some new ideas advanced in this small work, that will prove a lasting benefit to the human family, in relieving the suffering and pain to which they are subject, is the heartfelt desire of the author.

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